National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Invasive Exotic Plant Monitoring at Herbert Hoover National Historic Site

Year 2 (2009)

Natural Resource Technical Report NPS/HTLN/NRTR—2010/289

ON THE COVER
Restored prairie at Herbert Hoover National Historic Site

Invasive Exotic Plant Monitoring at Herbert Hoover National Historic Site

Year 2 (2009)

Natural Resource Technical Report NPS/HTLN/NRTR—2010/289

Craig C. Young, Mary F. Short, Lloyd W. Morrison, Chad S. Gross, and Jennifer L. Haack
National Park Service
Heartland I&M Network
Wilson's Creek National Battlefield
6424 West Farm Road 182, Republic, MO 65738

Heartland Network
Natural Resource Monitoring

February 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the Heartland I&M Network website (http://www.nature.nps.gov/im/units/HTLN) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

Please cite this publication as:

Young, C. C., M. F. Short, L. W. Morrison, C. S. Gross, and J. L. Haack. 2010. Invasive exotic plant monitoring at Herbert Hoover National Historic Site: Year 2 (2010). Natural Resource Technical Report NPS/HTLN/NRTR—2010/289. National Park Service, Fort Collins, Colorado.

Contents

Page

Figures v

Tables vii

Abstract ix

Introduction 1

Methods 1

Watch lists 1

Field methods 1

Analytical methods 2

Invasiveness ranks 3

Results and Discussion 3

Literature Cited 7

Figures

Page

Figure 1. Invasive exotic plant search units at Herbert Hoover National Historic Site – Main Unit. 8

Figure 2. Abundance and distribution of *Arctium minus* (lesser burdock) at Herbert Hoover National Historic Site, 2006 and 2009.. 13

Figure 3. Abundance and distribution of *Bromus inermis* (smooth brome) at Herbert Hoover National Historic Site, 2006 and 2009... 14

Figure 4. Abundance and distribution of *Calystegia sepium* (hedge false bindweed) at Herbert Hoover National Historic Site, 2006 and 2009. 15

Figure 5. Abundance and distribution of *Carduus nutans* (nodding plumeless thistle) at Herbert Hoover National Historic Site, 2006 and 2009. 16

Figure 6. Abundance and distribution of *Chenopodium album (*lambsquarters) at Herbert Hoover National Historic Site, 2006 and 2009. 17

Figure 7. Abundance and distribution of *Cirsium arvense (*Canada thistle) at Herbert Hoover National Historic Site, 2006 and 2009.. 18

Figure 8. Abundance and distribution of *Cirsium vulgare* (bull thistle) at Herbert Hoover National Historic Site, 2006 and 2009... 19

Figure 9. Abundance and distribution of *Dactylis glomerata* (orchardgrass) at Herbert Hoover National Historic Site, 2006 and 2009. 20

Figure 10. Abundance and distribution of *Daucus carota* (Queen Anne's lace) at Herbert Hoover National Historic Site, 2006 and 2009. 21

Figure 11. Abundance and distribution of *Elaeagnus* spp. (autumn / Russian olive) at Herbert Hoover National Historic Site, 2006 and 2009. 22

Figure 12. Abundance and distribution of *Elymus repens* (quackgrass) at Herbert Hoover National Historic Site, 2006 and 2009... 23

Figure 13. Abundance and distribution of *Glechoma hederacea* (ground ivy) at Herbert Hoover National Historic Site, 2006 and 2009.. 24

Figure 14. Abundance and distribution of *Lotus corniculatuss* (bird's-foot trefoil) at Herbert Hoover National Historic Site, 2006 and 2009. 25

Figure 15. Abundance and distribution of *Lonicera* spp. (honeysuckle shrub) at Herbert Hoover National Historic Site, 2006 and 2009. 26

Figure 16. Abundance and distribution of *Melilotus officinalis* (yellow sweetclover) at Herbert Hoover National Historic Site, 2006 and 2009. 27

Figure 17. Abundance and distribution of *Morus alba* (white mulberry) at Herbert Hoover National Historic Site, 2006 and 2009. 28

Figure 18. Abundance and distribution of *Pastinaca sativa* (wild parsnip) at Herbert Hoover National Historic Site, 2006 and 2009. 29

Figure 19. Abundance and distribution of *Phalaris arundinacea* (reed canarygrass) at Herbert Hoover National Historic Site, 2006 and 2009. 30

Figure 20. Abundance and distribution of *Phleum pratense* (Timothy) at Herbert Hoover National Historic Site, 2006 and 2009. 31

Figure 21. Abundance and distribution of *Poa* spp. (Kentucky and Canada bluegrass) at Herbert Hoover National Historic Site, 2006 and 2009 32

Figure 22. Abundance and distribution of *Rhamnus cathartica* (common buckthorn) at Herbert Hoover National Historic Site, 2006 and 2009 33

Figure 23. Abundance and distribution of *Rosa multiflora* (multiflora rose) at Herbert Hoover National Historic Site, 2006 and 2009 34

Figure 24. Abundance and distribution of *Securigera varia* (crownvetch) at Herbert Hoover National Historic Site, 2006 and 2009 35

Figure 25. Abundance and distribution of *Sonchus arvensis* (field sowthistle) at Herbert Hoover National Historic Site, 2006 and 2009 36

Figure 26. Abundance and distribution of *Trifolium pratense* (red clover) at Herbert Hoover National Historic Site, 2006 and 2009. 37

Figure 27. Abundance and distribution of *Ulmus pumila* (Siberian elm) at Herbert Hoover National Historic Site, 2006 and 2009. 38

Figure 28. Abundance and distribution of *Verbascum thapsus* (common mullein) at Herbert Hoover National Historic Site, 2006 and 2009. 39

Tables

Page

Table 1. Watch lists for Herbert Hoover National Historic Site. 9

Table 2. Overview of invasive exotic plants found on Herbert Hoover National Historic Site in 2006 and 2009.. 11

Abstract

During surveys in 2009, we documented 23 invasive exotic plant taxa in the restored prairie at Herbert Hoover National Historic Site. The most widespread and abundant of the exotic plant species observed included sweetclover, reed canarygrass, and smooth brome. Prevalent mainly in the western half of the prairie, sweetclover was established on at least 0.8 acres. Reed canarygrass and smooth brome each covered a minimum of 1 acre. Out of the 23 invasive exotic plants, 17 species each occurred on less than one acre. Similar surveys were conducted and documented in 2006, providing an opportunity to compare two separate years of data collection, as well as an analysis of changes in invasive exotic plant composition, abundance and distribution at the park. Seven of 27 species increased in frequency, while 20 decreased. Given that three of the five species showing high relative increases in frequency are weedy perennials with low ecological impacts, extraordinary control efforts are not warranted. Nine of 19 species with decreasing frequencies received some sort of mechanical or chemical treatment during 2006 to 2009. While sweetclover continued to be widespread at the park., mowing dramatically reduced its overall abundance in the prairie. Five additional species increased in abundance, although these increases were slight in terms of the area occupied. The information presented in the report may be used to plan management activities leading to control of exotic plants and the accomplishment of GPRA goal IA1b.

Introduction

An invasive exotic plant is a plant species that is not native to an area and is presumed to pose environmental harm to native plant populations or communities. In general, invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss as threats to global biodiversity (Scott and Wilcove 1998). Prevention and early detection are the principal strategies for successful invasive exotic plant management. Invasive exotic plants often undergo a lag period between introduction and subsequent colonization of new areas. Managers can take advantage of monitoring efforts to detect invasive exotic species early and initiate control actions before populations become well established (Welch and Geissler 2007).

The restored prairie at Herbert Hoover National Historic Site is a significant cultural resource that is vulnerable to exotic plant invasions. A number of highly invasive exotic plants have already become established. These plants include crownvetch (*Securigera varia*), reed canarygrass (*Phalaris arundinacea*), smooth brome (*Bromus inermis*), and sweetclover (*Melilotus officinalis*). Currently, the park is planning a project to control invasive plants and replant native species along drainages within the restored prairie. In 2009, the park used a combination of chemical and mechanical methods (mowing and hand-pulling) to control invasive plant species.

Methods

Watch lists

The invasive exotic plants on three watch lists were sought during monitoring (Table 1). Invasive exotic plants not known to occur on the park according to NPSpecies (the national NPS database for plant occurrence registration) constitute the "Early Detection Watch List". Invasive exotic plants known to occur on the park according to NPSpecies constitute the "Park-Established Watch List". The "Park-Based Watch List" includes exotic plants, selected by park managers or network staff, which may not have been included on the other lists due to incomplete information in NPSpecies (e.g., not documented) or USDA Plants (e.g., state distribution information inaccurate) databases, or due to differing opinions regarding network designation of a species as a high priority. While aquatic species are included on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented only occasionally.

Field methods

Invasive exotic plant species on designated watch lists (Table 1) were sought in Herbert Hoover National Historic Site (Figure 1) during July 7-8, 2006 and July 21-22, 2009. Karola Mlekush and Craig Young conducted the survey in 2006 and 2009, while Tyler Cribbs assisted in 2006 and Maria Gaetani assisted in 2009. Ashely Dunkle recorded data in 2009, but did not make observations. Observers navigated along three transects through each search unit, identified invasive exotic plants in a 3 m- to 12 m-belt and attributed a coarse cover value to each species (0=0, 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 $\geq$ 1,000 m^2). Observers spaced themselves approximately equidistantly along the east or west border of a search unit prior to searching the unit in an easterly or westerly direction. Transects, however, were not marked, such that the exact position of each transect may have varied between years. The widest belt possible given site conditions was used. A total of 50 search units were surveyed (Figure 1). Unit size ranged between 0.372 – 3.468 acres with a mean size of 1.67 acres. A total of 26% of search units ranged between 1.5 and 1.7 acres, while 60% of search units were between 1.2 and 2.0 acres in size.

In this study, all observed shrub honeysuckles were documented as *Lonicera* spp. To facilitate ease of field identification between Kentucky and Canada bluegrass (*Poa pratensis* and *Poa compressa*, respectively), both species were categorized as *Poa* spp. and were analyzed as a single taxon. Similarly, we did not distinguish autumn olive (*Elaeagnus umbellata*) and Russian olive (*Elaeagnus angustifolia*), which we recorded as *Elaeagnus* spp.

Analytical methods

Data analysis involved simple displays, as well as calculation of plant cover and frequency. The invasive exotic plants encountered on Herbert Hoover National Historic Site were attributed to search units in a GIS (Figures 2 – 28). Note that entire search units were not fully searched. A park-wide cover range was estimated for each invasive exotic plant encountered.

We calculated the observed reference frame fraction by multiplying transect length, the number of transects, and the belt width. The belt width was either 3 m (the minimum possible width) or 12 m (the maximum possible width). The product was then divided by the reference frame area (Eq. 1). We calculated transect lengths using the mean sample unit size and assuming square search units.

$$\text{Eq. 1. Fraction of area searched} = \frac{\textit{transect length * number of transects * belt width}}{\textit{reference frame area}}$$

The minimum fraction of area searched (belt width = 3 m) was 0.109, and the maximum fraction of area searched (belt width = 12 m) was 0.437.

To calculate the minimum end of the estimated cover range for each species, we summed the lower endpoints associated with the assigned cover class values for that species and then divided by the reference frame fraction observed assuming the widest possible survey belt (i.e., maximum fraction observed) (12 m) (Eq. 2).

$$\text{Eq. 2. Minimum cover estimate} = \frac{\Sigma \textit{ low end of cover value range for species}}{\textit{fraction of area searched assuming 12-m belt width}}$$

Maximum cover for each species was calculated similarly, using the upper endpoints of the cover values in each occupied search unit and assuming that a 3 m belt was surveyed (i.e., minimum fraction of area observed) (Eq. 3).

$$\text{Eq. 3. Maximum cover estimate} = \frac{\Sigma \textit{ high end of cover value range for species}}{\textit{fraction of area searched assuming 3-m belt width}}$$

Taken together, the minimum and maximum cover estimates provide an estimated range of cover that accounts for the uncertainty arising from the sampling method. Non-overlapping ranges represent the strongest evidence for differences in abundance.

The park-wide frequency of invasive exotic plants was calculated as the percentage of occupied search units (Eq. 4).

$$\text{Eq. 4. Frequency of an IEP species} = \frac{\Sigma \textit{ units occupied by species}}{\Sigma \textit{ units sampled}} \text{ X100}$$

Invasiveness ranks

To provide additional information on the ecological impact and feasibility of control, the ecological impact and general management difficulty sub-ranks that constitute the invasiveness rank (I-rank), as determined by NatureServe (Morse et al. 2004), were listed when available. The ecological impact characterizes the effect of the plant on ecosystem processes, community composition and structure, native plant and animal populations, and the conservation significance of threatened biodiversity. General management difficulty ranks are assigned based on the resources and time generally required to control a plant, the non-target effects of control on native populations, and the accessibility of invaded sites. Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), or a combination of ranks.

Results and Discussion

In 2006 and 2009, a total of 27 unique invasive exotic plant taxa were found during the surveys at Herbert Hoover National Historic Site. We found 25 species in 2006 and 23 species in 2009 (Table 2). The majority (n=17) of the invasive exotic plant species identified during the surveys were known to occur at Herbert Hoover National Historic Site due to the park's strong botanical record. During these surveys, we documented seven invasive exotic plants from the park-based list and three species from the early detection watch list. The early detection species included: common buckthorn (*Rhamnus cathartica*), crownvetch (*Securigera varia*), and nodding plumeless thistle (*Carduus nutans*).

The distribution and abundance of the invasive exotic plant species at Herbert Hoover National Historic Site varied widely in 2009. Sweetclover (*Melilotus officinalis*), the most widespread invasive species on the park, covered at least 0.8 acres of the prairie. Two perennial cool-season invasive grasses were also widespread and abundant in 2009: reed canarygrass (*Phalaris arundinacea*) and smooth brome (*Bromus inermis*). The estimated cover of reed canarygrass and smooth brome, both roughly unchanged from 2006 to 2009, each exceeded 1 acre. Eight other invasive exotic plant species displayed park-wide cover (maximum estimate) in excess of 0.5 acres in 2009: bluegrass (*Poa* spp.), hedge false bindweed (*Calystegia sepium*), lesser burdock (*Arctium minus*), Queen Anne's lace (*Daucus carota*), Russian / autumn olive (*Elaeagnus* spp.), shrub honeysuckle (*Lonicera* spp.), white mulberry (*Morus alba*), and wild parsnip (*Pastinaca sativa*). We documented all of the aforementioned species during the 2006 survey with the exception of lesser burdock. Timothy (*Phleum pratense*) was the only other species not reported in 2006. Four invasive exotic plant species found in 2006 were not observed in the park in 2009: quackgrass (*Elymus repens*), nodding plumeless thistle, orchardgrass (*Dactylis glomerata*), and common buckthorn.

Comparisons of invasive plant abundance and frequency between 2006 and 2009 required careful consideration of the uncertainty associated with the measurements outlined in the monitoring protocol (Young et al 2007). We recognized two sources of uncertainty when analyzing occurrence (i.e., frequency) patterns within or between years. First, observers can make mistakes in their observations to include overlooking or misidentifying plants within transects. The use of trained botanists and technicians is intended to minimize this source of uncertainty. Second, because transect locations and widths may vary between years, differences in plant detection may reflect natural spatial variability. This factor may strongly affect plant detection rates in any single search unit, but should vary randomly across all units. Such sampling error, which should be mitigated through the approximately similar location of transects between years, poses the greatest challenge to data interpretation in this protocol. While we observed a high portion of the reference frame compared to traditional sampling approaches (Young and Haack 2009), observers cannot observe all areas of the park. Additional observations from park staff or citizen scientists would increase detection of invasive plant species.

With these sources of error in mind, we interpreted the three possible scenarios that characterize changes in the frequency of invasive plant species between 2006 and 2009: In the first scenario, a species found within a search unit during the first and second sampling periods confirmed the longevity of the species in that location. In the second scenario, in which a species was not found in a search unit during either sampling period, we assumed that the species was absent or at least not highly abundant or widely distributed as these characteristics would increase detection probabilities. The third scenario–when a species found in a search unit during one sampling period and not during the next–was the most problematic. This observation could reflect species turnover or a dramatic fluctuation in abundance that is typically associated with annual species. For this dataset, however, we assumed that in most cases the species was probably present during both sampling periods. We attributed the absence either to observer mistakes, which we expect are minimal, or to sampling error arising from the use of non-permanent transects and variable belt widths along transects.

The assumption made here for the third scenario will not always be appropriate. For example, a species that is not found or found at low frequency during an early sampling period and is then found in a relatively large number of search units during a later sampling period may be actively invading. Alternatively, for species subject to control actions, decreases in frequency between or among surveys could result from such management. Relatively dramatic changes in frequency, however, will only be expected for species with low abundance that respond readily to management techniques. In either case, such patterns will be best documented by increasing or decreasing trends from several years of survey data.

Only seven of the 27 invasive plant species increased in frequency between 2006 and 2009. The increase was slight to moderate for hedge bindweed, shrub honeysuckle, and sweetclover, which were all already common in 2006, occurring in at least 50% of the search units. Sweetclover was mowed prior to flowering in 2009, shrub honeysuckle was cut incidentally between 2006 and 2009, and field bindweed was untreated. We observed relatively large increases on a relative basis for three species that were uncommon in 2006 (occurring in < 10% of the search units): field sowthistle (*Sonchus arvensis*), Queen Anne's lace, and red clover (*Trifolium pratense*). Lesser burdock and timothy were not present in 2006, but found at a low frequency in 2009. Given that three of these latter five species are weedy perennials with low ecological impacts, immediate control efforts are not warranted. Queen Anne's lace and red clover were subjected to incidental pulling between 2006 and 2009, while the other species were untreated. Timothy, however, should be closely watched, given its medium ranking for ecological impact and management difficulty.

Nineteen species decreased in frequency between 2006 and 2009. Of these, 10 were not specifically targeted with treatments. Six of these decreasing species - white mulberry (*Morus alba*), Russian/autumn olive, Siberian elm (*Ulmus pumila*), multiflora rose (*Rosa multiflora*), and common buckthorn - were incidentally cut and treated with herbicide during woody plant control efforts. Targeting reed canarygrass and smooth brome with glyphosate treatments in search units 1, 2, and 3 could not have greatly reduced park-wide frequency given the localized effects, although hand-pulling of nodding plumeless thistle in the same units may have reduced a concentration of this species on the park. Canada thistle (*Cirsium arvense*), which was cut across the park in 2009, decreased in frequency by 66%. Crownvetch (*Securigera varia*), which was not treated, was the only species that did not change in frequency between 2006 and 2009.

We examined the entire suite of invasive exotic plant species to assess general changes in frequency between 2006 and 2009. While treatments directed at individual plant species or areas may confound this approach, this pattern may provide an assessment of generalized treatment effects, particularly for widely-applied treatments such as prescribed fire. Prairie management units 1, 2, 3, 4, and 7 were burned in 2005, while units 1 and 6 and 1, 5, 6, and 7 were burned in 2008 and 2009, respectively (Figure 1). Given that sampling error between years should be random (i.e., expected value for increasing and decreasing categories = 50%), we found that for the twenty species with maximum abundance ≤ 1.2 acres in 2009, 65% of species decreased in frequency between 2006 and 2009, while 30% of species increased and 5% remained static. Of the 13 species that decreased in frequency during those years, 54% showed decreases of at least 25% on a relative basis, and 31% were not encountered at all in 2009. For the seven species with maximum frequency > 1.2 acres, 71% of species decreased in frequency, while 29% of the species increased. All changes were slight to moderate with the exception of smooth brome, which decreased sharply from frequency of 80% in 2006 to 48% in 2009. Based on the documented sensitivity of cool season grasses to fire, we assumed that fire accounted for the reduced frequency in bluegrass, orchardgrass, smooth brome, and timothy.

Interpreting changes in the abundance of invasive plant species between 2006 and 2009 required considerations of uncertainty in addition to those made for frequency. For example, in addition to observer detection mistakes, abundance estimates include error resulting from incorrect assignment of cover classes. As with detection, abundance estimation may vary between years due to variability in transect location, although the approximate similarity in location between years should mitigate this error. The uncertainty resulting from measurement error (i.e., the use of cover class ranges rather than point estimates) and the uncertainty resulting from variable belt widths are accounted for in the cover range provided for each invasive plant species (see *Analytical Methods*). For the purposes of comparing cover ranges for each species between 2009 and 2006, non-overlapping cover ranges represent the strongest evidence for a change in the abundance of a species between 2006 and 2009. Cover ranges may be very broad, however, and increase with abundance. Thus, relatively large differences in overlapping cover ranges could also be informative. For such overlapping cover ranges, the degree of the difference in overlap should be proportional to the strength of evidence for a true difference in abundance. Consequently, a high degree of overlap in range represents a lower probability of a difference than a low degree of overlap.

Based on non-overlapping cover ranges, we identified only three species as changing in abundance between 2006 and 2009: crown vetch, Queen Anne's lace, and red clover increased in abundance. However, we observed these species at very low abundance levels, and the differences in cover were extremely small. Lesser burdock and timothy increased in abundance from 0 in 2006 to at least 0.06 and <0.01 acres, respectively. Although cover ranges overlapped, sweetclover cover presumably decreased between 2006 and 2009, even as the number of park search units containing the species increased slightly. This finding suggests that mowing substantially decreased sweetclover cover, although sweetclover remained established throughout the park. With the exception of sweetclover, we interpreted the rest of the overlapping ranges as reflecting general similarity in abundance between 2006 and 2009. Viewing the entire suite of invasive species with abundance greater than 0 during 2006 and 2009 as a whole (n=21), the maximum cover estimate remained static for 19% of species, decreased for 33% of species, and increased for 48% of species.

Only three species were noted as having unambiguously high ecological impact in 2009: reed canary grass, crownvetch, and Russian/autumn olive (Table 2). Three species were characterized as having at least a medium ecological impact; the remaining species had ambiguous medium-low ecological impacts or less, including seven species with low or insignificant impacts. Reed canarygrass and Canada thistle were ranked as species generating high management difficulty; however, the majority of the species are of little management concern with ratings of only medium to insignificant management difficulty. Recognizing that the feasibility of control often strongly influences decisions regarding invasive exotic plant management, crownvetch and autumn olive with high ecological impacts were noted as having low management difficulty. Additionally, many invasive exotic species occurred on less than half of an acre. Controlling these species will likely provide a high benefit for the management costs.

Literature Cited

Morse, L. E., J. M. Randall, N. Benton, R. D. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity. Version 1. Document. Online. (http://www.natureserve.org/getData/plantData.jsp#InvasivesProtocol). Accessed: December 1, 2006.

Scott, J. M. and D. S. Wilcove. 1998. Improving the future for endangered species. Bioscience 48(8): 579-80.

Welch, B. A. and P. H. Geissler. 2007. Early detection of invasive plants: a handbook. United States Geological Survey draft. Online. (http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm). Accessed February 19, 2010.

Williamson, M. and A. Fitter. 1996. The varying success of invaders. Ecology 77:1661–1666.

Young, C. C., J. L. Haack, L. W. Morrison, and M. D. DeBacker. 2007. Invasive Exotic Plant Monitoring Protocol for the Heartland Network Inventory and Monitoring Program. Natural Resource Report NPS/HTLN/NRR-2007/018. National Park Service, Fort Collins, Colorado.

Young C. C. and J. L. Haack. 2009. A rapid, invasive plant survey method for national park units with a cultural resource focus. Park Science 26:70-75.

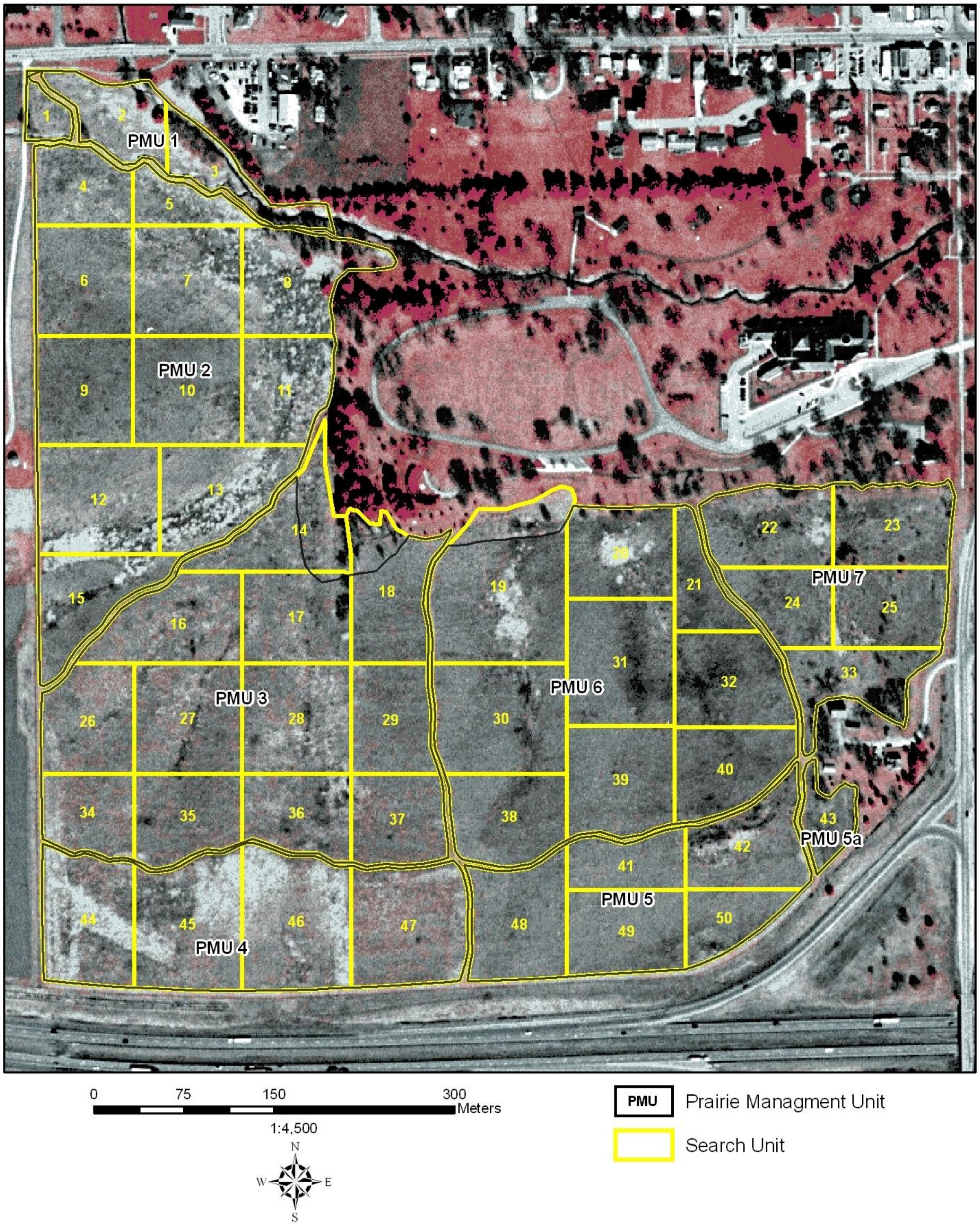

Figure 1. Invasive exotic plant search units at Herbert Hoover National Historic Site – Main Unit. The search units indicate the search locations for invasive exotic plants in 2006 and 2009, while the prairie management units represent areas that serve as the basis for implementing restoration projects.

Table 1. Watch lists for **Herbert Hoover National Historic Site**. The symbol ^ denotes aquatic plant species.

Early Detection Watch List		Park-Established Watch List		Park-Based Watch List	
Ailanthus altissima	Tree of heaven	*Arctium minus*	Lesser burdock	*Abutilon theophrastii*	Velvetleaf
Alliaria petiolata	Garlic mustard	*Bromus inermis*	Smooth brome	*Acer platanoides*	Norway maple
Alnus glutinosa	European alder	*Bromus tectorum*	Cheatgrass	*Calystegia sepium*	Hedge false bindweed
Azolla	Mosquitofern	*Cirsium arvense*	Canada thistle	*Chenopodium album*	Lambsquarters
Berberis thunbergii	Japanese barberry	*Cirsium vulgare*	Bull thistle	*Daucus carota*	Queen anne's lace
Carduus nutans	Nodding plumeless thistle	*Dactylis glomerata*	Orchardgrass	*Elymus repens*	Quackgrass
Celastrus orbiculatus	Oriental bittersweet	*Elaeagnus angustifolia*	Russian olive	*Euonymus atropurpureus*	Burningbush
Centaurea biebersteinii	Spotted knapweed	*Elaeagnus umbellata*	Autumn olive	*Polygonum spp*	Knotweed
Centaurea solstitialis	Yellow star-thistle	*Glechoma hederacea*	Ground ivy	*Sonchus arvensis*	Field sowthistle
Dipsacus fullonum	Fuller's teasel	*Hesperis matronalis*	Dames rocket	*Trifolium hybridum*	Alsike clover
Dipsacus laciniatus	Cutleaf teasel	*Lonicera morrowii*	Morrow's honeysuckle	*Trifolium pratense*	Red clover
Euonymus alata	Burning bush	*Lonicera tatarica*	Tatarian honeysuckle		
Euphorbia esula	Leafy spurge	*Lotus corniculatus*	Bird's-foot trefoil		
Frangula alnus	Glossy buckthorn	*Melilotus officinalis*	Sweetclover		
Holcus lanatus	Common velvetgrass	*Morus alba*	White mulberry		
Humulus japonicus	Japanese hop	*Pastinaca sativa*	Wild parsnip		
Hydrilla verticillata	Waterthyme	*Phalaris arundinacea*	Reed canarygrass		
Hyoscyamus niger	Black henbane	*Phleum pratense*	Timothy		
Lespedeza bicolor	Shrub lespedeza	*Poa pratensis*	Kentucky bluegrass		
Lespedeza cuneata	Sericea lespedeza	*Potentilla recta*	Sulphur cinquefoil		
Ligustrum vulgare	European privet	*Robinia pseudoacacia*	Black locust		
Schedonorus phoenix	Tall fescue	*Rosa multiflora*	Multiflora rose		
Schedonorus pratensis	Meadow fescue	*Solanum dulcamara*	Climbing nightshade		
Lonicera maackii	Amur honeysuckle	*Ulmus pumila*	Siberian elm		
Lysimachia nummularia	Creeping jenny	*Verbascum thapsus*	Common mullein		
Lythrum salicaria	Purple loosestrife				
Myriophyllum spicatum^	Eurasian watermilfoil				
Phragmites australis	Common reed				
Plantago lanceolata	Narrowleaf plantain				
Poa compressa	Canada bluegrass				
Polygonum cuspidatum	Japanese knotweed				
Populus alba	White poplar				

Table 1 (cont.). Watch lists for **Herbert Hoover National Historic Site**.

Early Detection Watch List		Park-Established Watch List		Park-Based Watch List	
Potamogeton crispus^	Curly pondweed				
Rhamnus cathartica	Common buckthorn				
Securigera varia	Crownvetch				
Sorghum halepense	Johnsongrass				
Torilis arvensis	Spreading hedgeparsley				
Typha angustifolia	Narrowleaf cattail				
Viburnum opulus	European cranberrybush				
Vinca minor	Common periwinkle				

Table 2. Overview of invasive exotic plants found on **Herbert Hoover National Historic Site** in 2006 and 2009. Inequalities rather than cover ranges are shown for species with maximum cover value less than 1 acre. Ecological impact and general management difficulty based on NatureServe I-Rank subranks, Morse et al. 2004. Subranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), a range of ranks (indicated by /), or not available (---).

Scientific Name	Common Name	Watch list	2006 Park-wide cover (acres)	2009 Park-wide cover (acres)	2006 Frequency (percent)	2009 Frequency (percent) (Frequency difference 2006 – 2009)	Ecological impact	Management difficulty
Melilotus officinalis	Sweetclover	Park-established	6.8 – 128.2	0.8 – 12.3	84	88 (4)	M	M
Phalaris arundinacea	Reed canarygrass	Park-established	1.9 – 30.7	1.3 – 26.0	50	48 (-2)	H	HM
Bromus inermis	Smooth brome	Park-established	0.7 – 8.6	1.4 – 16.6	80	48 (-32)	M	ML
Lonicera spp.	Honeysuckle shrub	Park-established	0.2 – 2.3	0.4 – 7.4	70	74 (4)	----	----
Morus alba	White mulberry	Park-established	0.1 – 2.1	0.1 – 2.0	68	64 (-4)	ML	ML
Pastinaca sativa	Wild parsnip	Park-established	0.1 – 1.7	0.3 – 3.9	70	66 (-4)	LI	L
Poa spp.	Kentucky / Canada Bluegrass	Park-established	0.04 – 1.1	0.2 – 3.1	90	82 (-8)	M / ML	ML / HM
Elaeagnus spp.	Autumn / Russian olive	Park-established	< 0.75	0.06 – 1.2	36	28 (-8)	H / HM	L / H
Chenopodium album	Lambsquarters	Park-based	< 0.5	< 0.1	16	6 (-10)	----	----
Lotus corniculatus	Bird's-foot trefoil	Park-established	< 0.5	< 0.1	10	4 (-6)	ML	ML
Ulmus pumila	Siberian elm	Park-established	< 0.5	< 0.5	18	12 (-6)	ML	ML
Calystegia sepium	Hedge false bindweed	Park-based	< 0.5	< 1.0	50	60 (10)	----	----
Cirsium arvense	Canada thistle	Park-established	< 0.5	< 0.5	18	10 (-8)	ML	HM
Sonchus arvensis	Field sowthistle	Park-based	< 0.25	< 0.1	8	12 (4)	LI	HL
Cirsium vulgare	Bull thistle	Park-established	< 0.25	< 0.25	12	4 (-8)	ML	ML
Glechoma hederacea	Ground ivy	Park-established	< 0.25	< 0.5	12	8 (-4)	LI	ML
Rosa multiflora	Multiflora rose	Park-established	< 0.1	< 0.25	18	16 (-2)	L	L
Verbascum thapsus	Common mullein	Park-established	< 0.1	< 0.01	14	2 (-12)	ML	L
Securigera varia	Crown vetch	Early-detection	< 0.1	< 0.25*	2	2 (0)	H	L
Elymus repens	Quackgrass	Park-based	< 0.1	0	20	0 (-20)	ML	HM
Carduus nutans	Nodding plumeless thistle	Early-detection	< 0.1	0	2	0 (-2)	MI	HM
Dactylis glomerata	Orchardgrass	Park-established	< 0.1	0	12	0 (-12)	LI	ML

Table 2 (cont.). Overview of invasive exotic plants found on **Herbert Hoover National Historic Site** in 2006 and 2009.

Scientific Name	Common Name	Watch list	2006 Park-wide cover (acres)	2009 Park-wide cover (acres)	2006 Frequency (percent)	2009 Frequency (percent) (Frequency difference 2006 – 2009)	Ecological impact	Management difficulty
Rhamnus cathartica	Common buckthorn	Early-detection	< 0.01	0	2	0 (-2)	M	M
Daucus carota	Queen Anne’s lace	Park-based	< 0.1	< 1.0*	6	22 (16)	I	I
Trifolium pratense	Red clover	Park-based	< 0.01	< 0.25*	2	8 (6)	LI	I
Arctium minus	Lesser burdock	Park-established	0	0.06 – 1.2	0	6 (6)	LI	MI
Phleum pratense	Timothy	Park-based	0	< 0.01	0	2 (2)	ML	M

*True difference in cover assumed based on non-overlapping cover ranges.

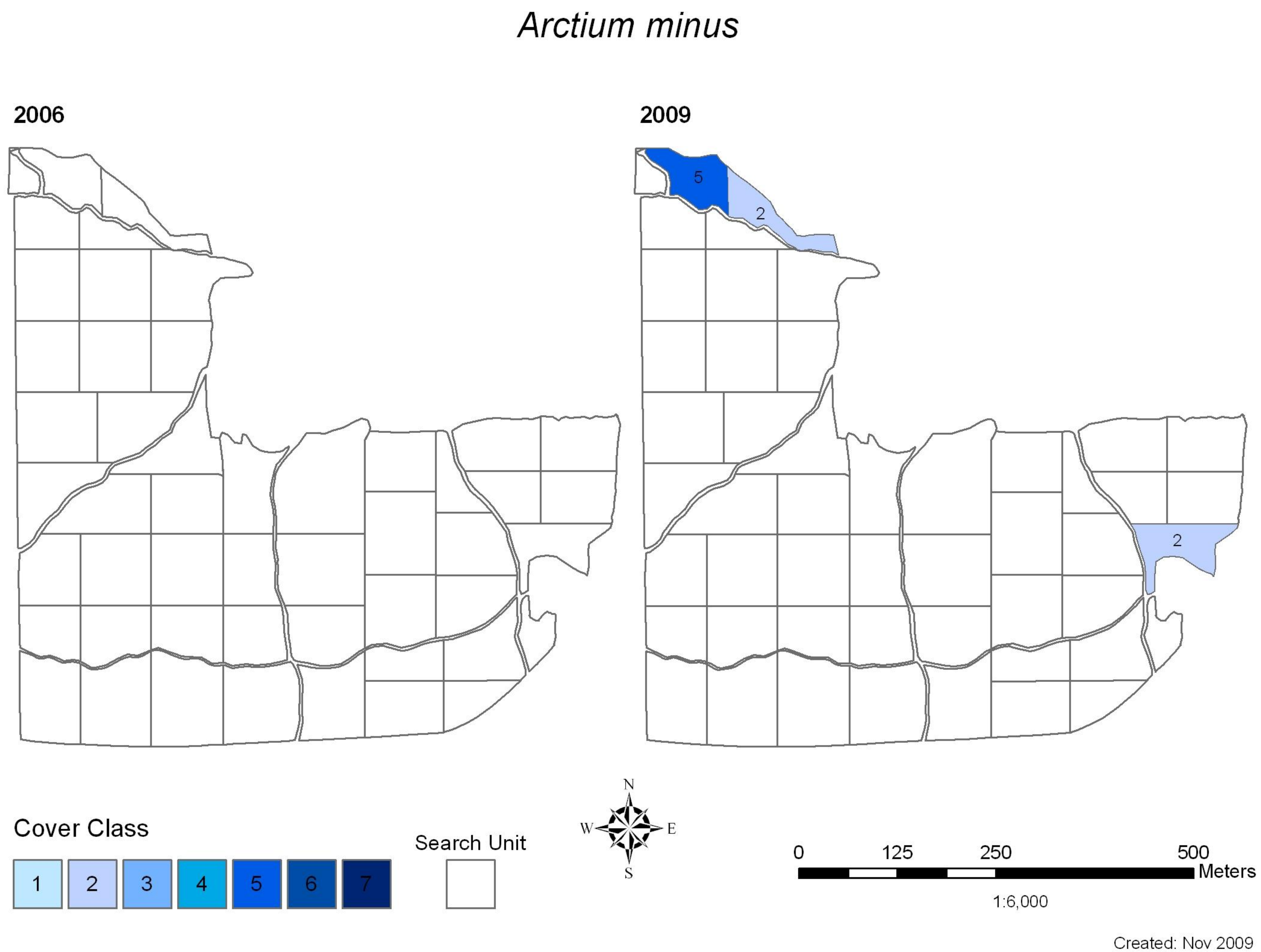

Figure 2. Abundance and distribution of *Arctium minus* (lesser burdock) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

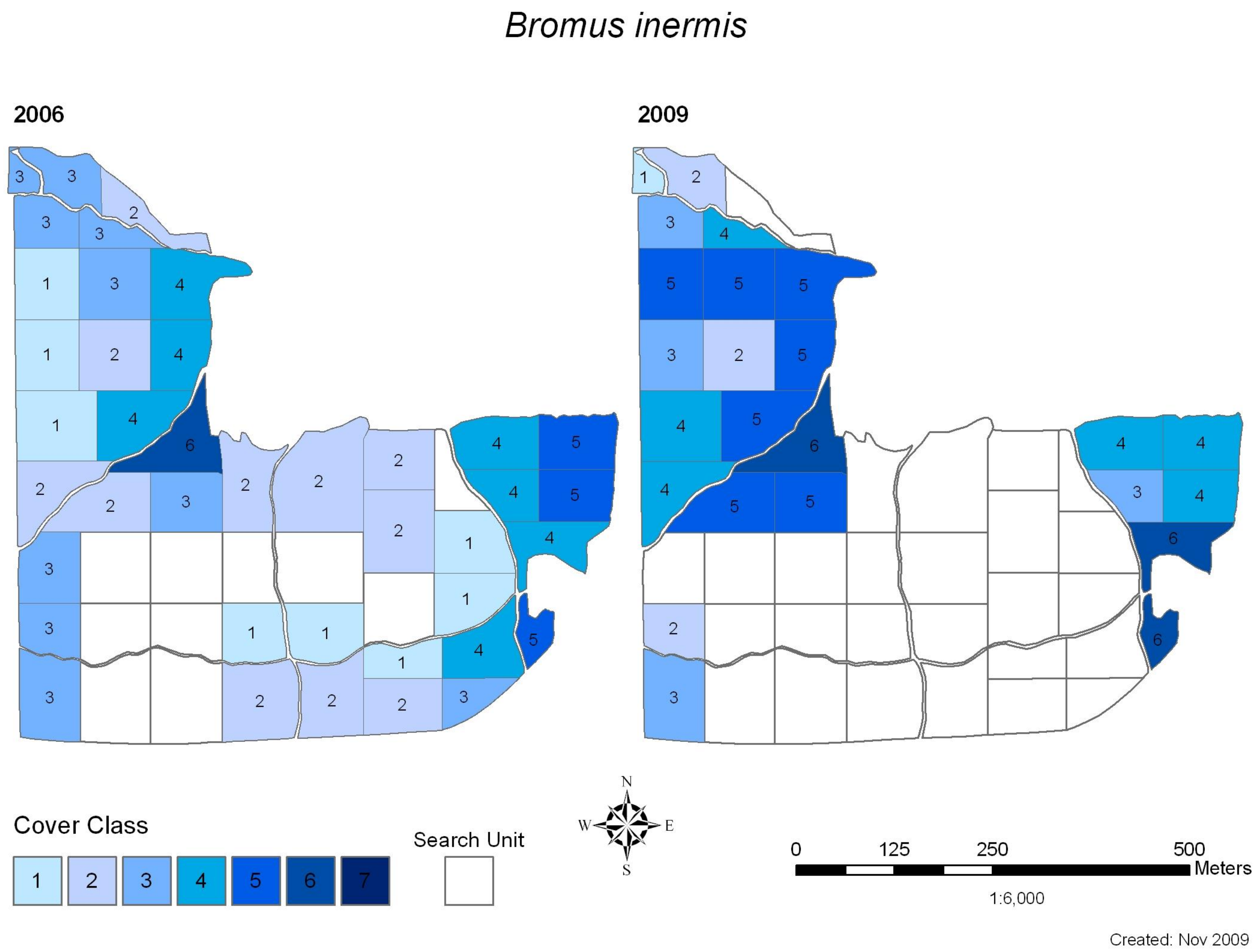

Figure 3. Abundance and distribution of *Bromus inermis* (smooth brome) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Calystegia sepium

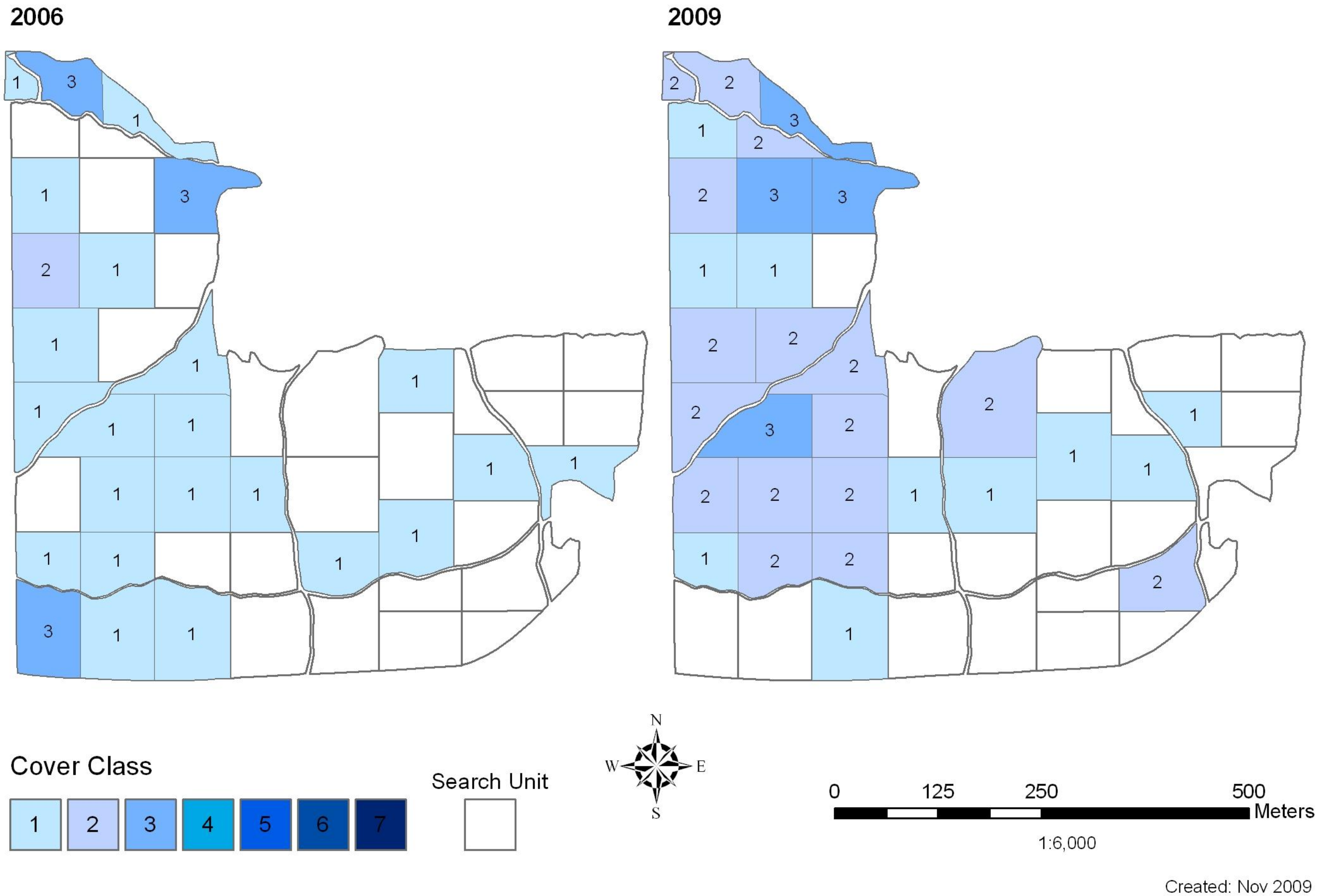

Figure 4. Abundance and distribution of *Calystegia sepium* (hedge false bindweed) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

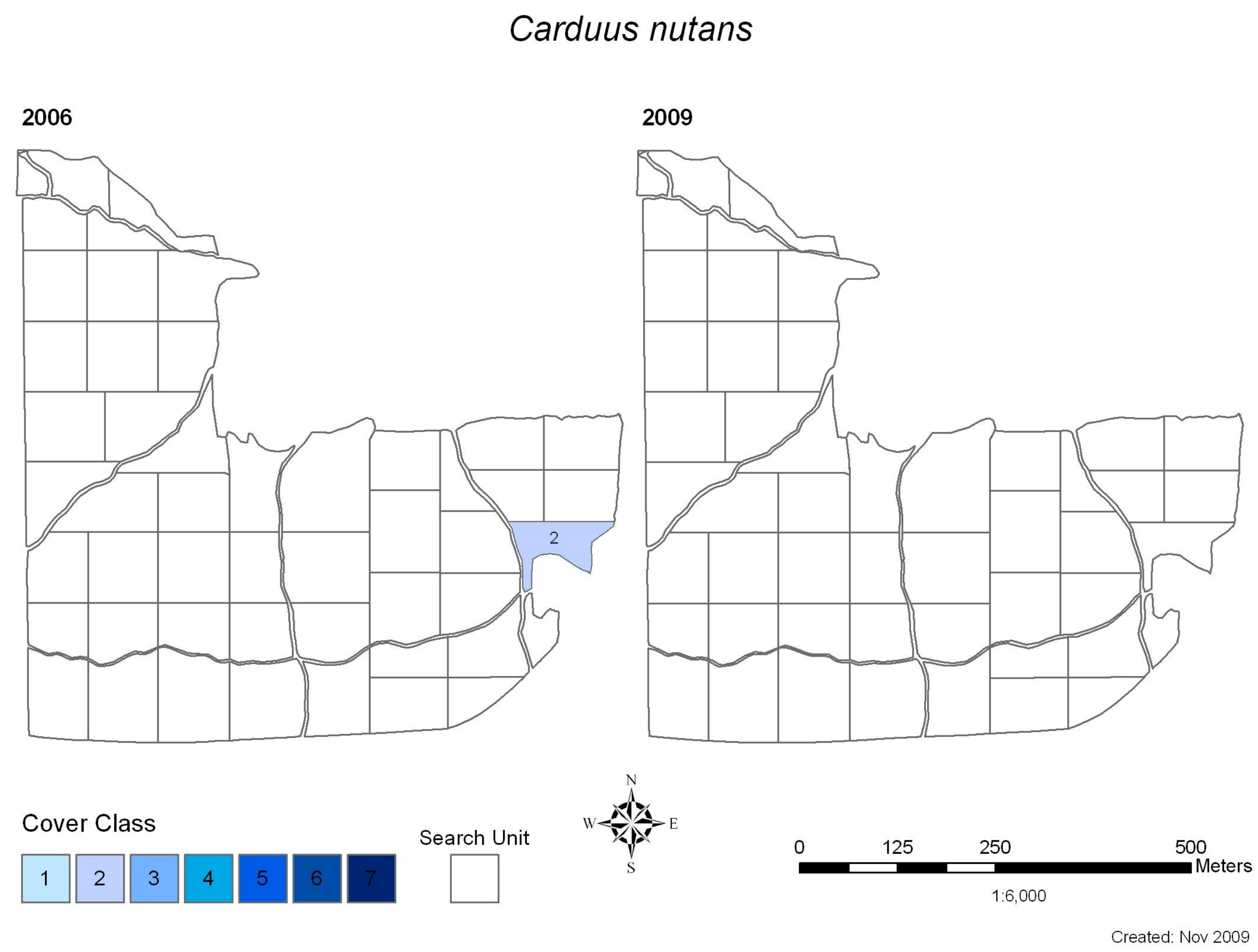

Figure 5. Abundance and distribution of *Carduus nutans* (nodding plumeless thistle) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

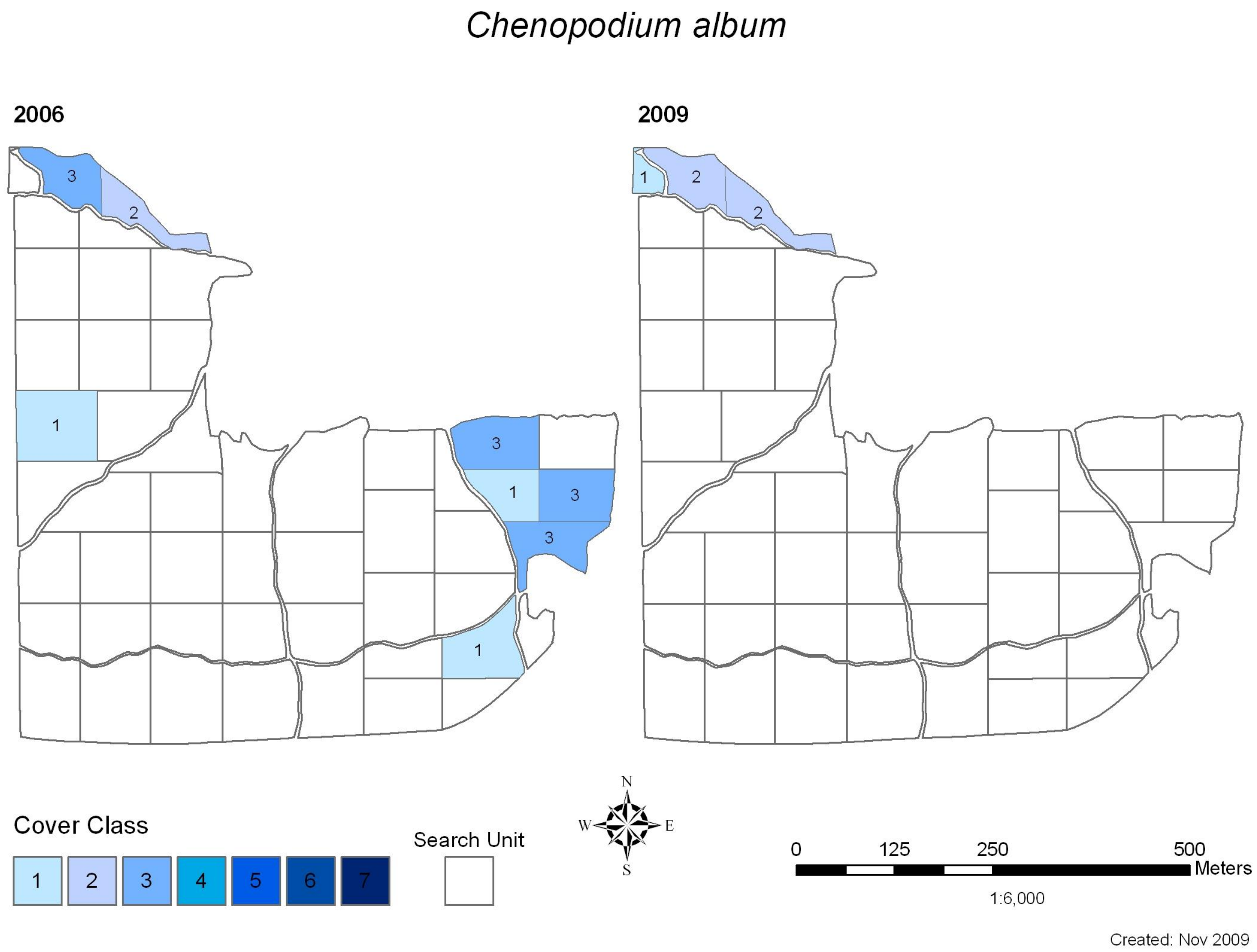

Figure 6. Abundance and distribution of *Chenopodium album (*lambsquarters) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

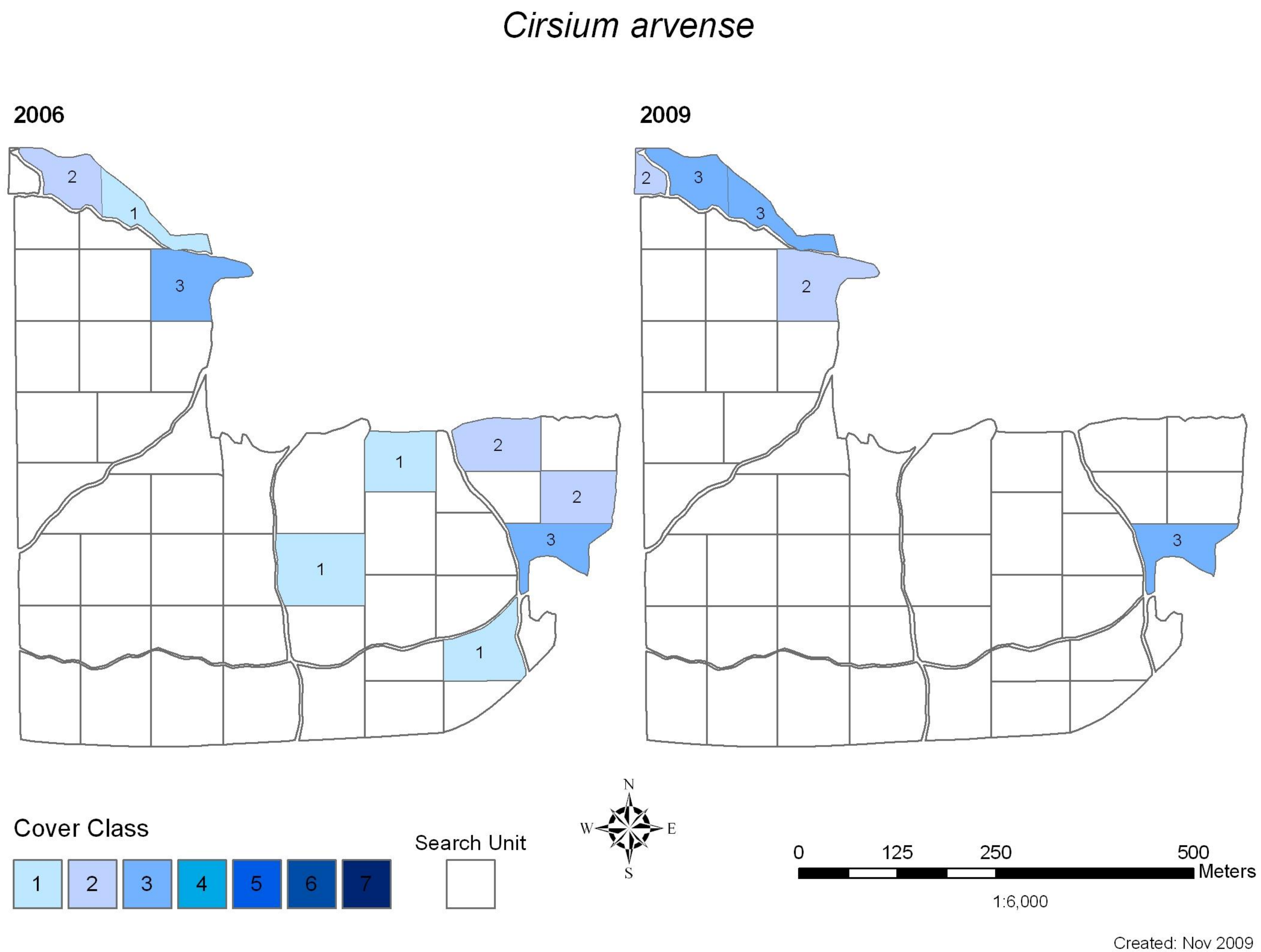

Figure 7. Abundance and distribution of *Cirsium arvense (*Canada thistle) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Cirsium vulgare

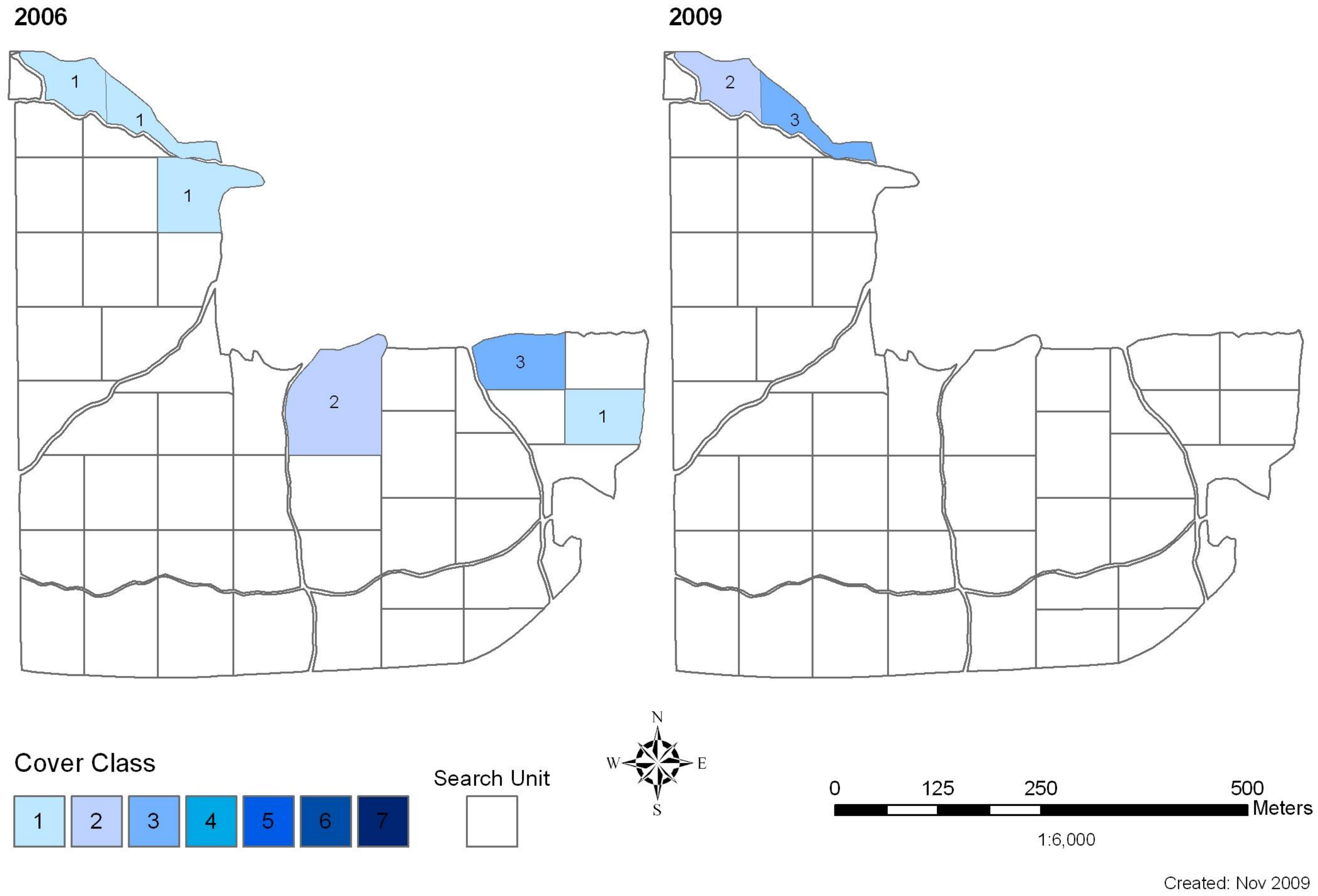

Figure 8. Abundance and distribution of *Cirsium vulgare* (bull thistle) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

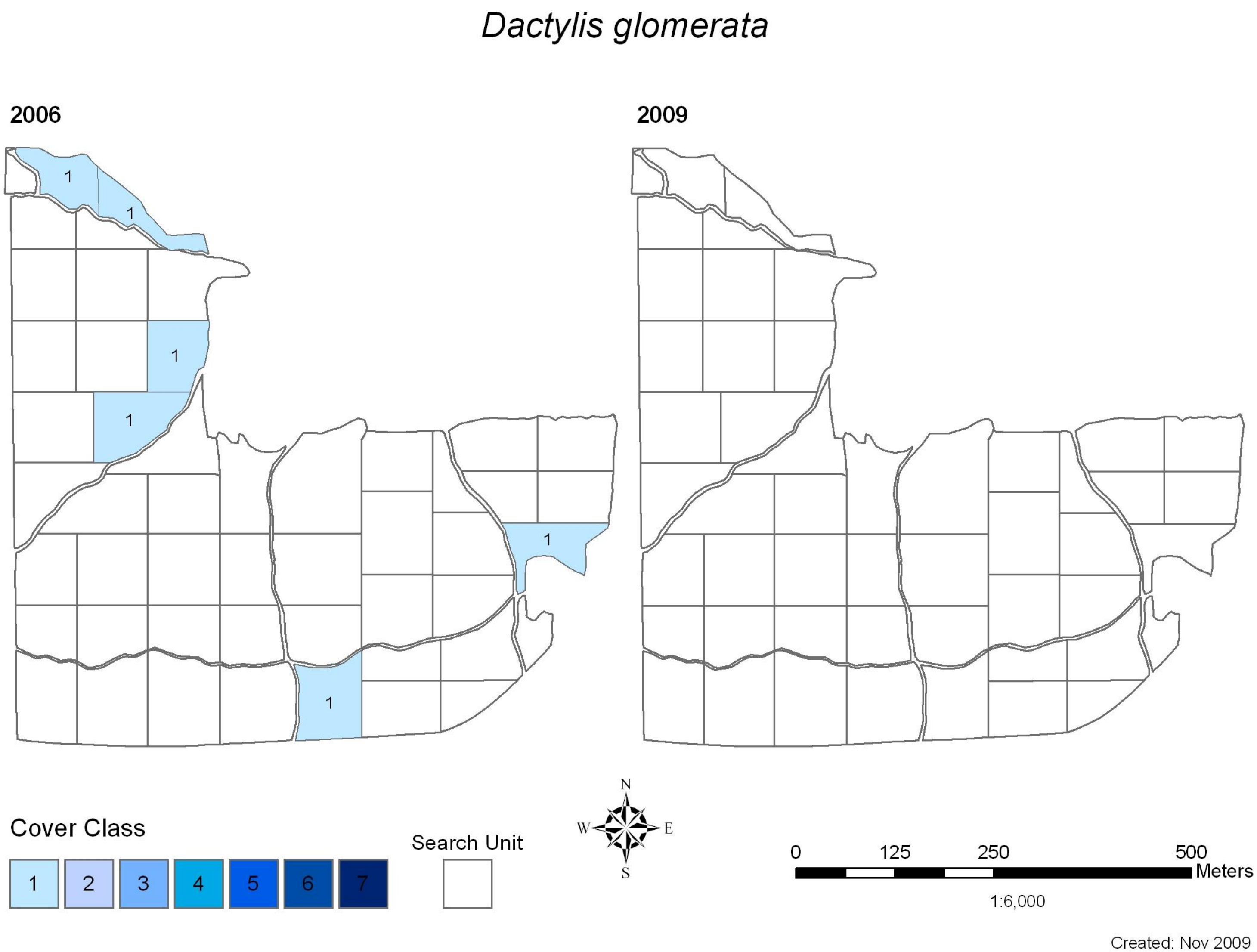

Figure 9. Abundance and distribution of *Dactylis glomerata* (orchardgrass) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 $\geq$ 1,000 m^2.

Daucus carota

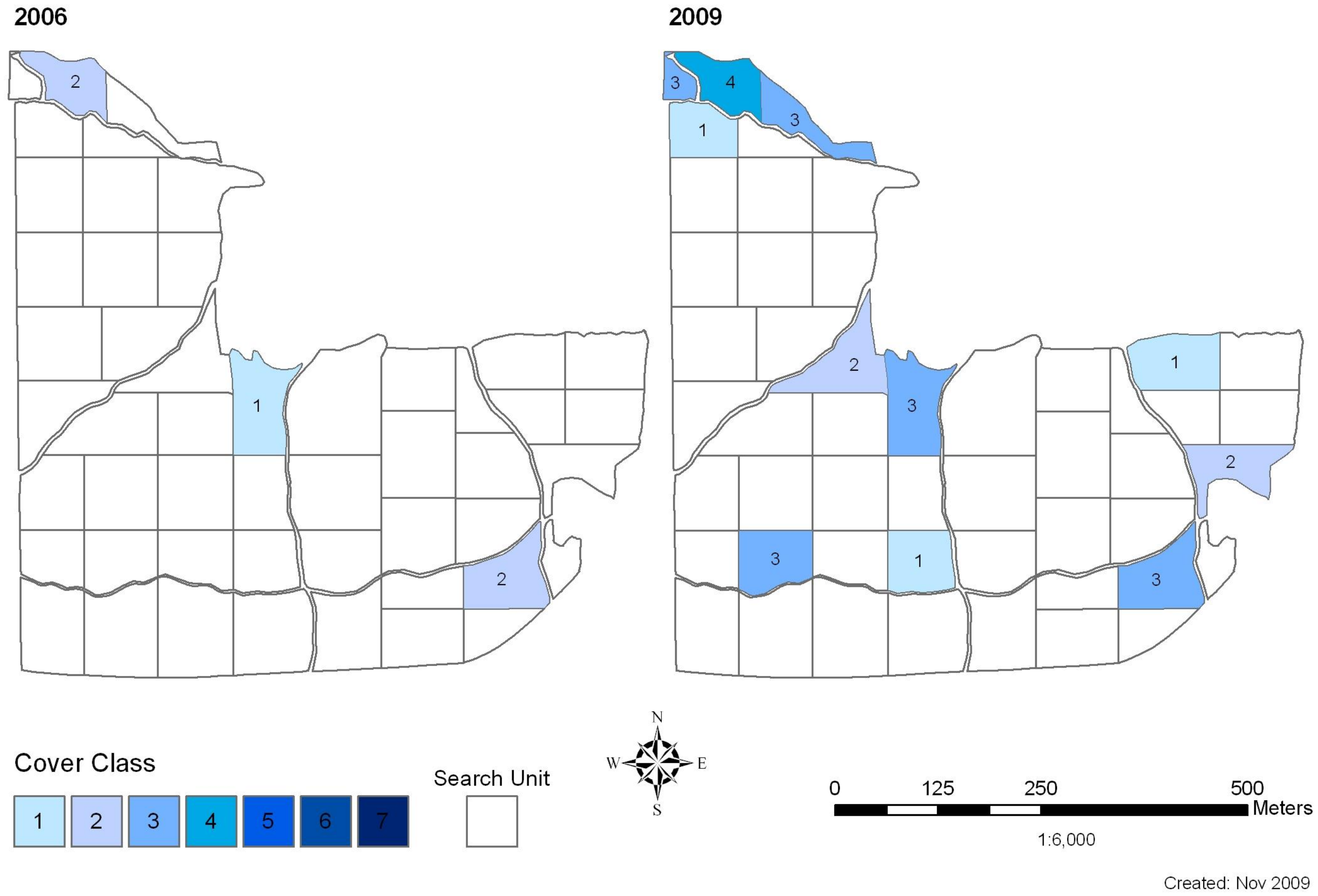

Figure 10. Abundance and distribution of *Daucus carota* (Queen Anne's lace) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

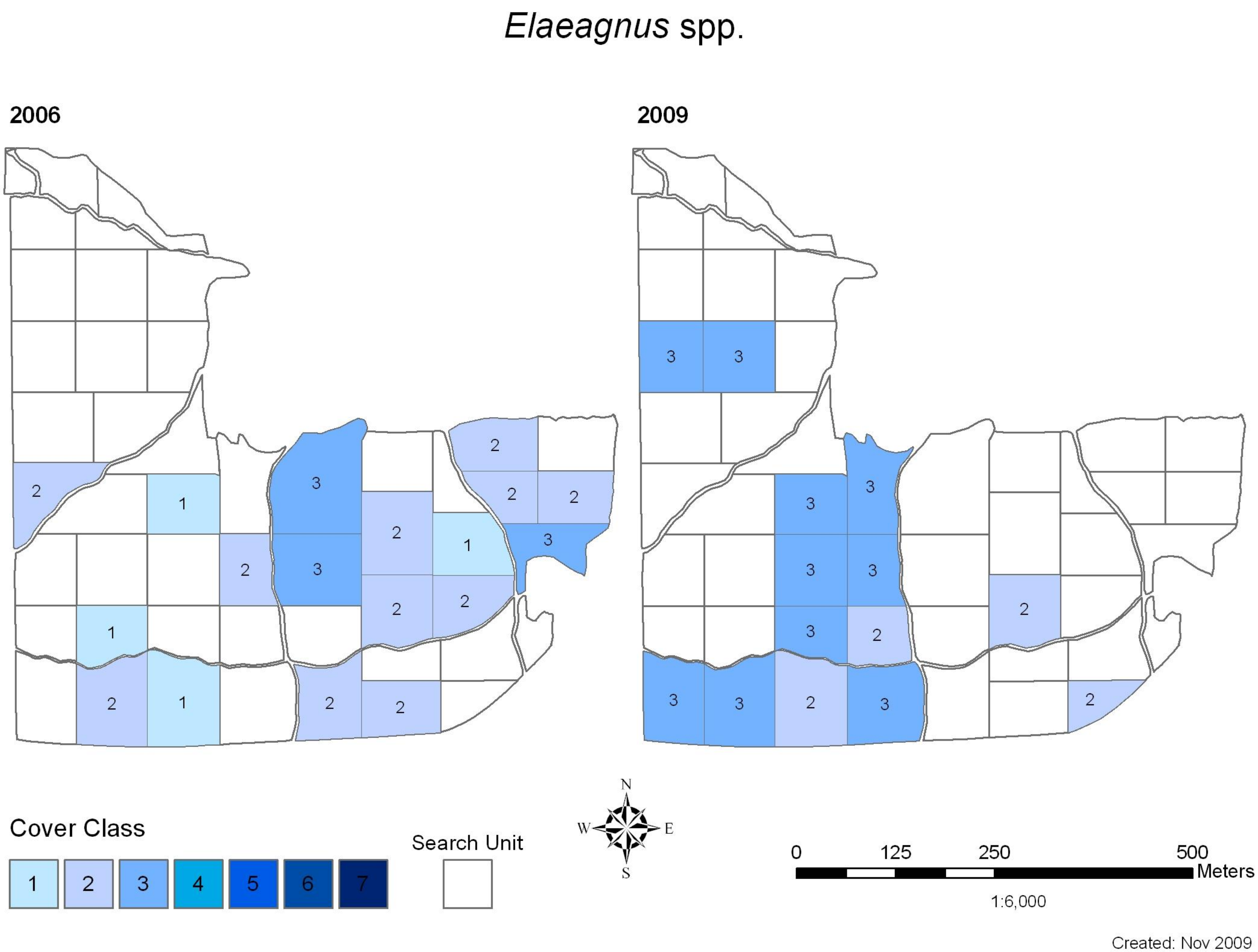

Figure 11. Abundance and distribution of *Elaeagnus* spp. (autumn / Russian olive) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

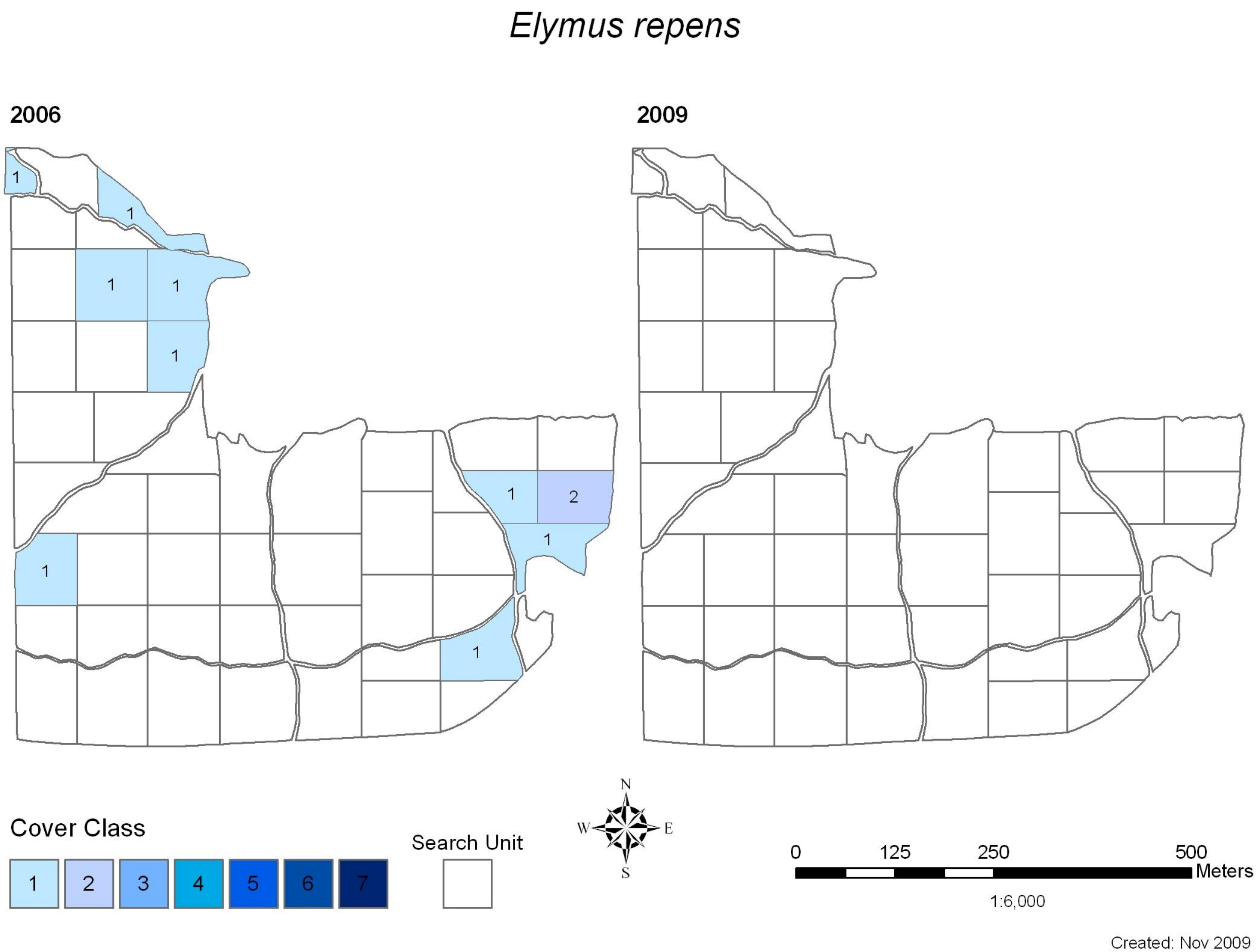

Figure 12. Abundance and distribution of *Elymus repens* (quackgrass) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Glechoma hederacea

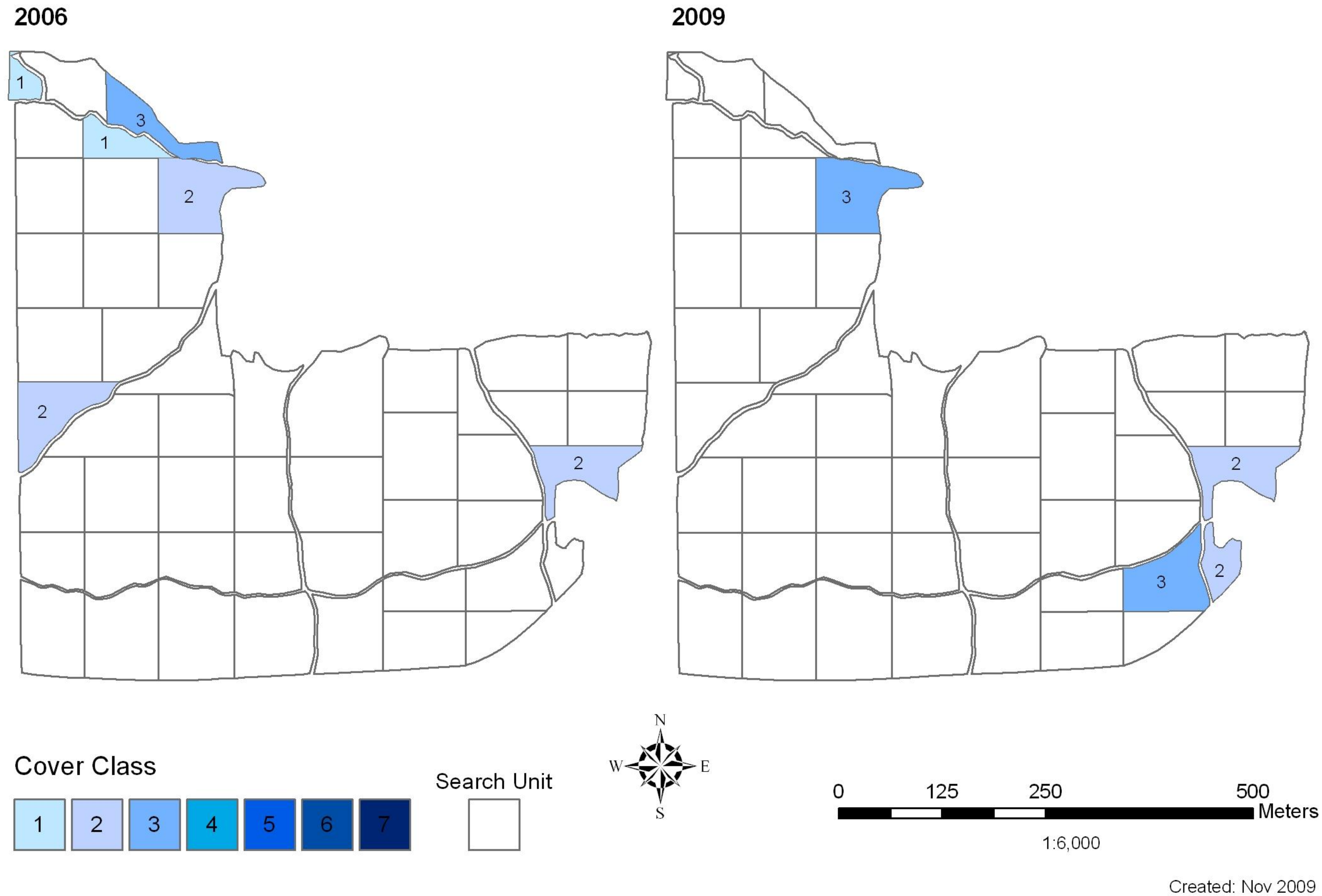

Figure 13. Abundance and distribution of *Glechoma hederacea* (ground ivy) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

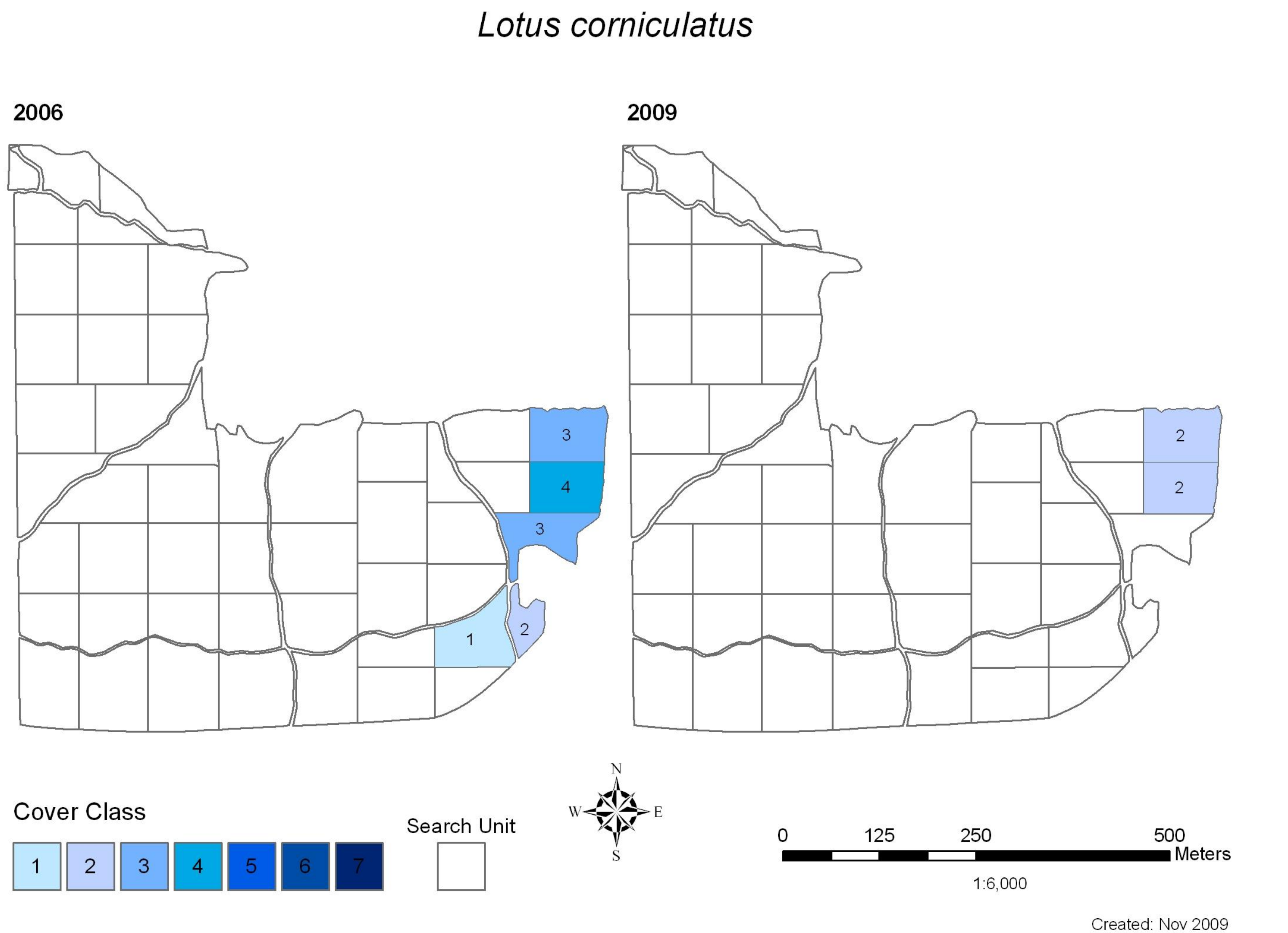

Figure 14. Abundance and distribution of *Lotus corniculatuss* (bird's-foot trefoil) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Lonicera spp.

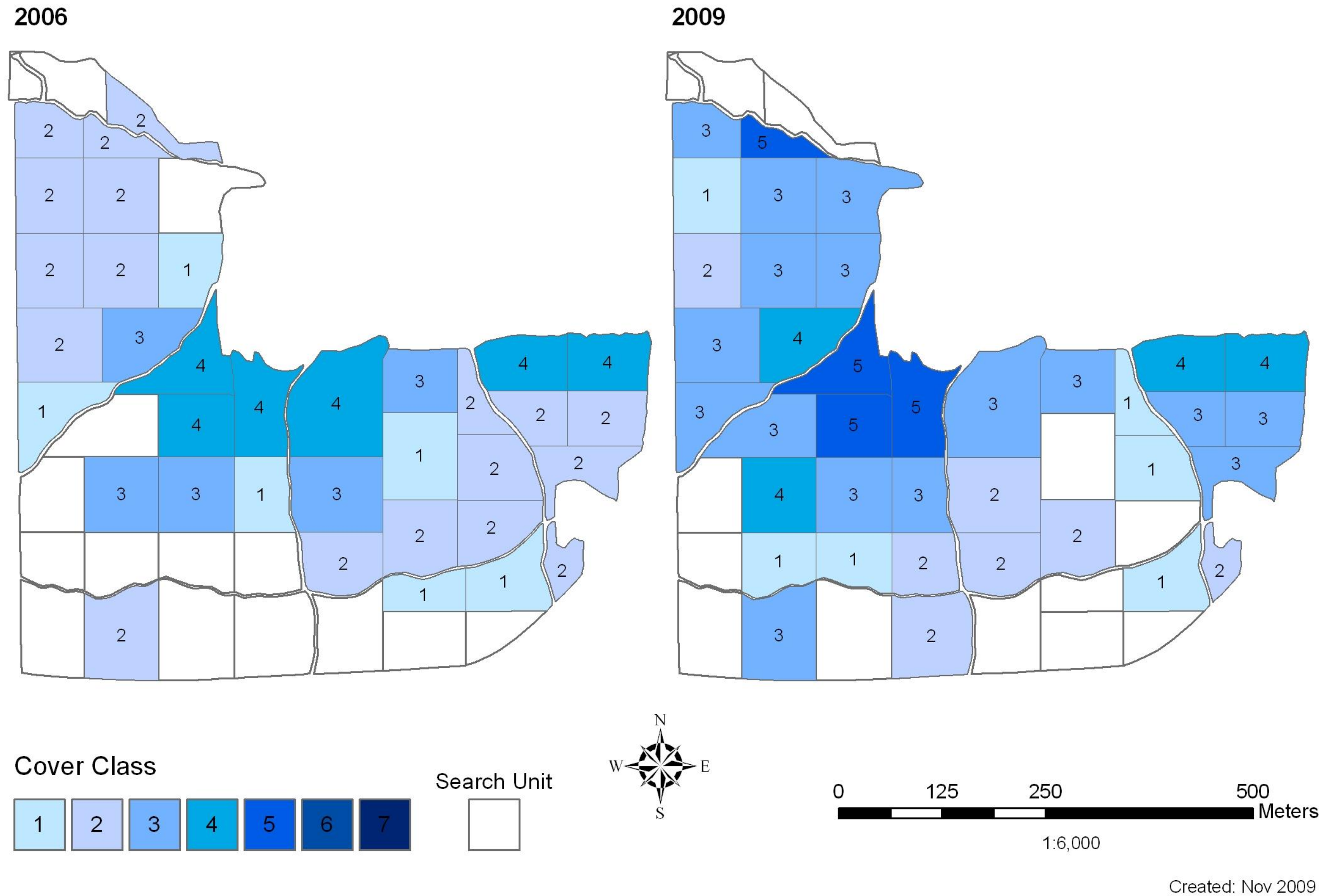

Figure 15. Abundance and distribution of *Lonicera* spp. (honeysuckle shrub) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

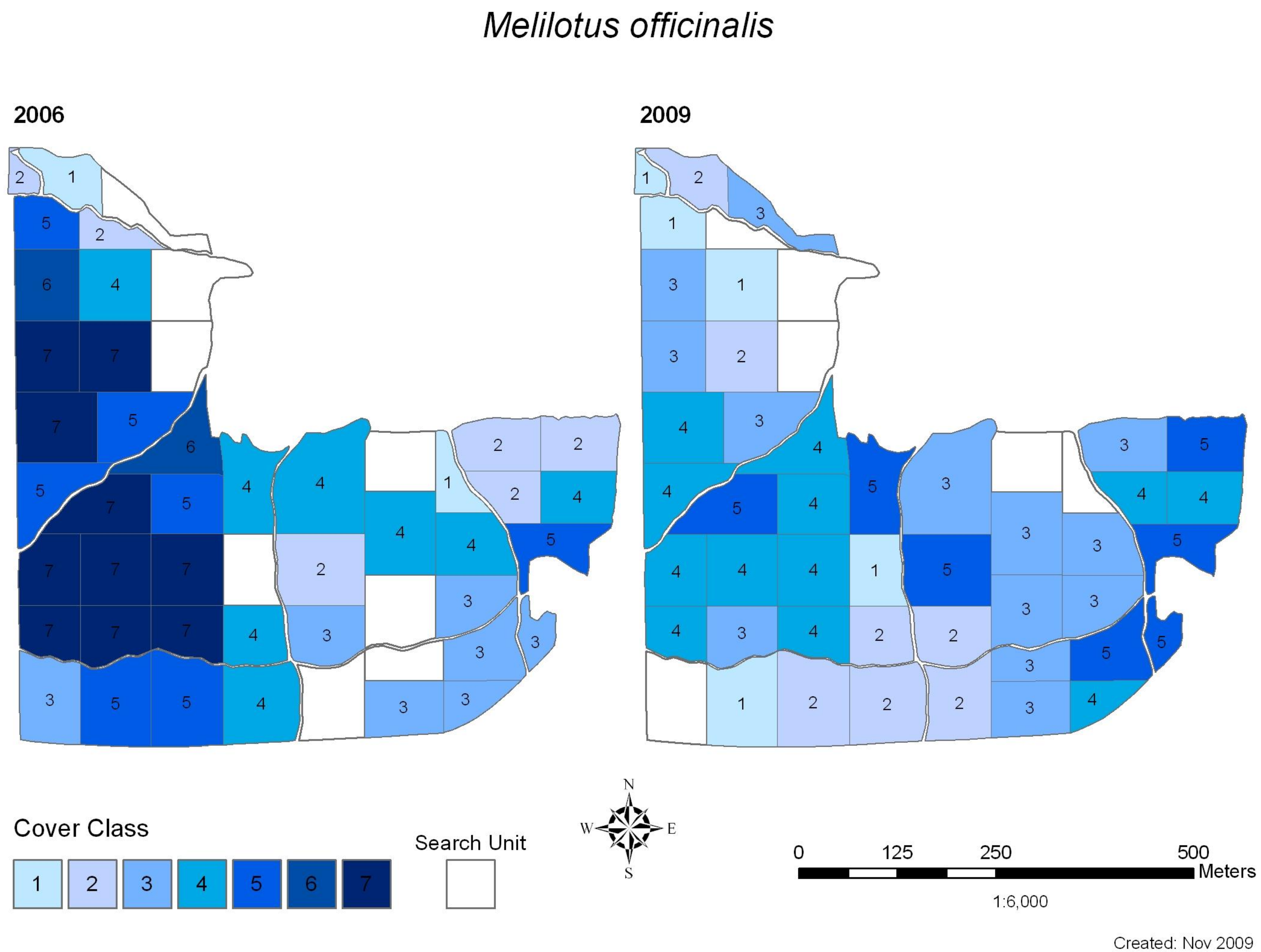

Figure 16. Abundance and distribution of *Melilotus officinalis* (sweetclover) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Morus alba

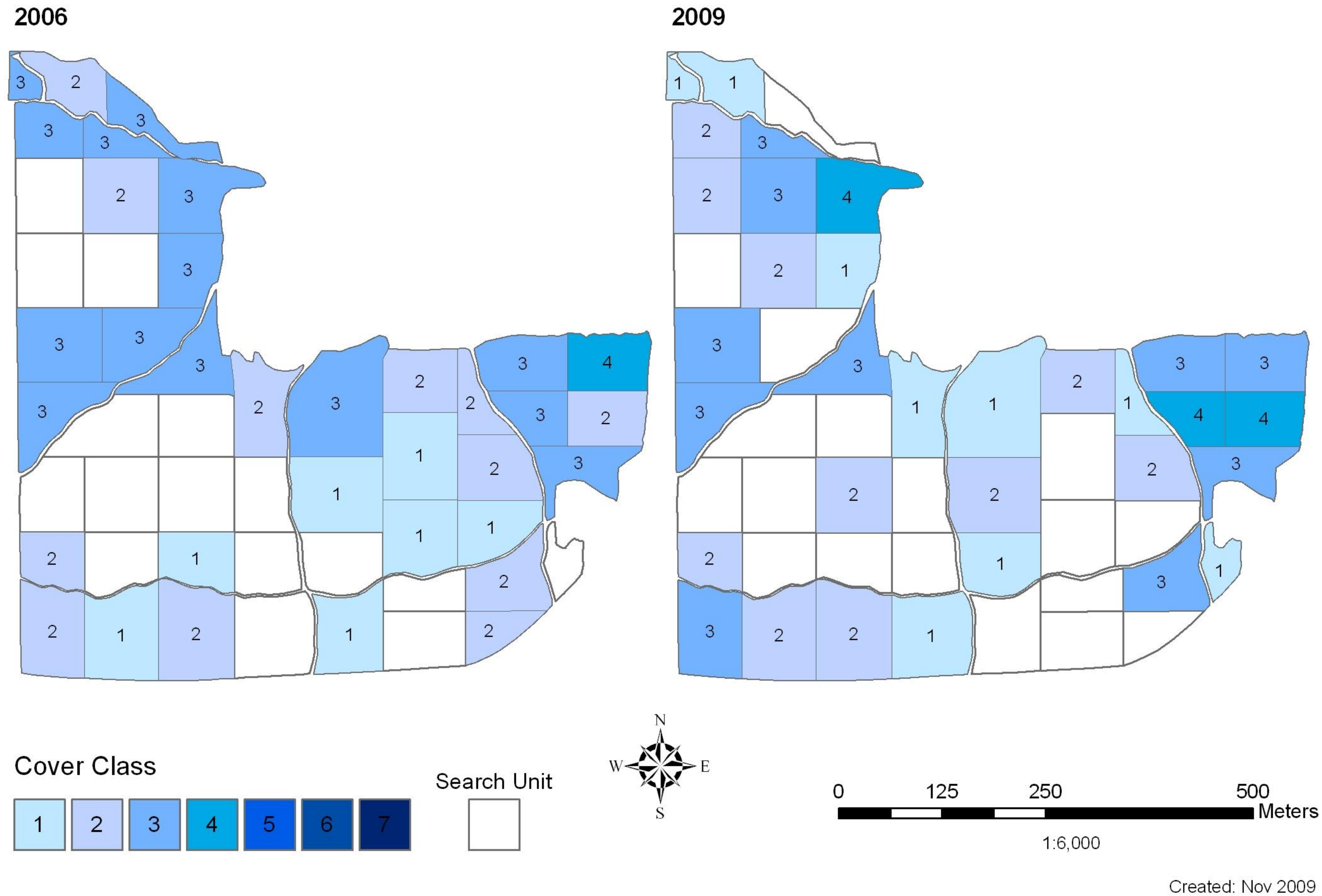

Figure 17. Abundance and distribution of *Morus alba* (white mulberry) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

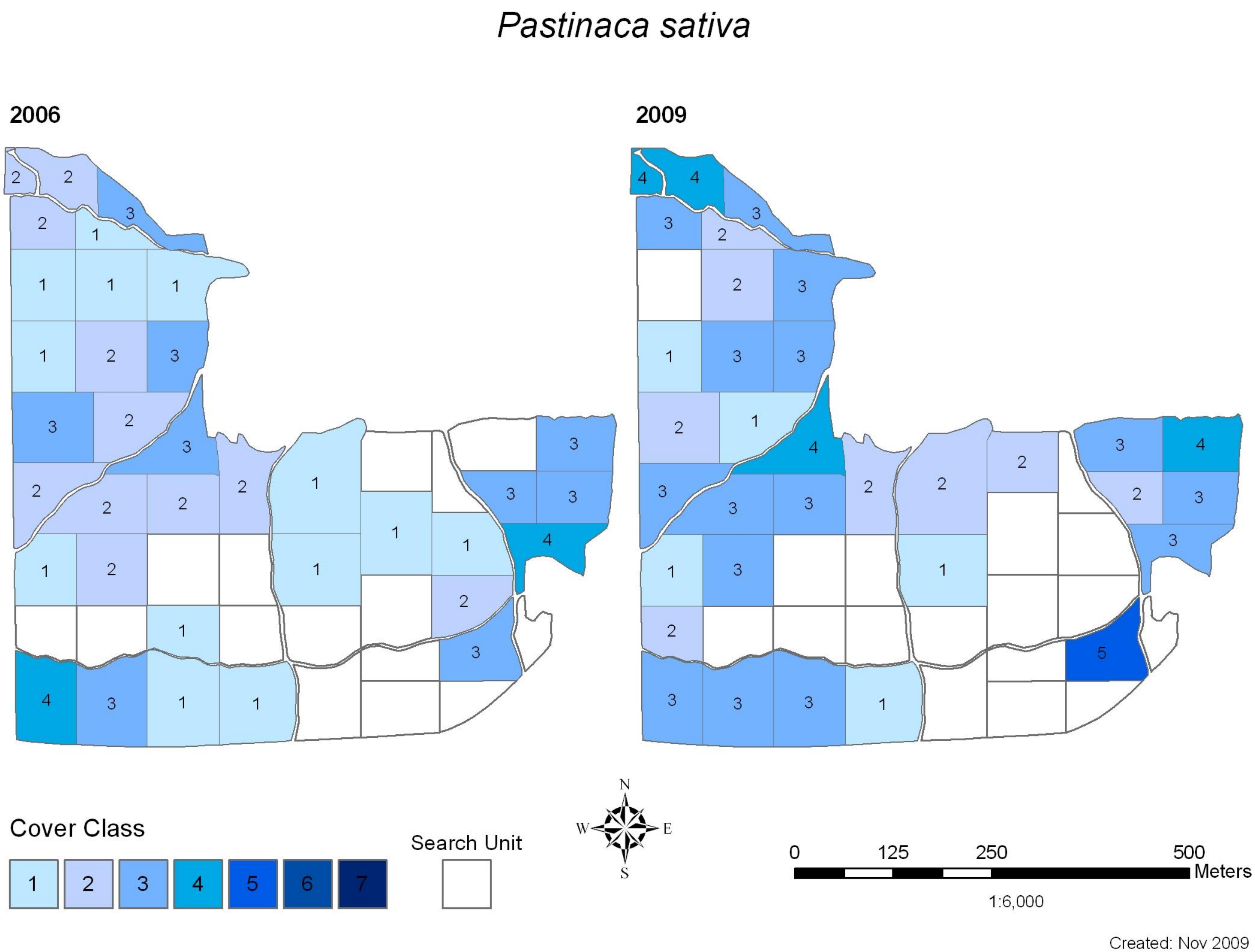

Figure 18. Abundance and distribution of *Pastinaca sativa* (wild parsnip) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Phalaris arundinacea

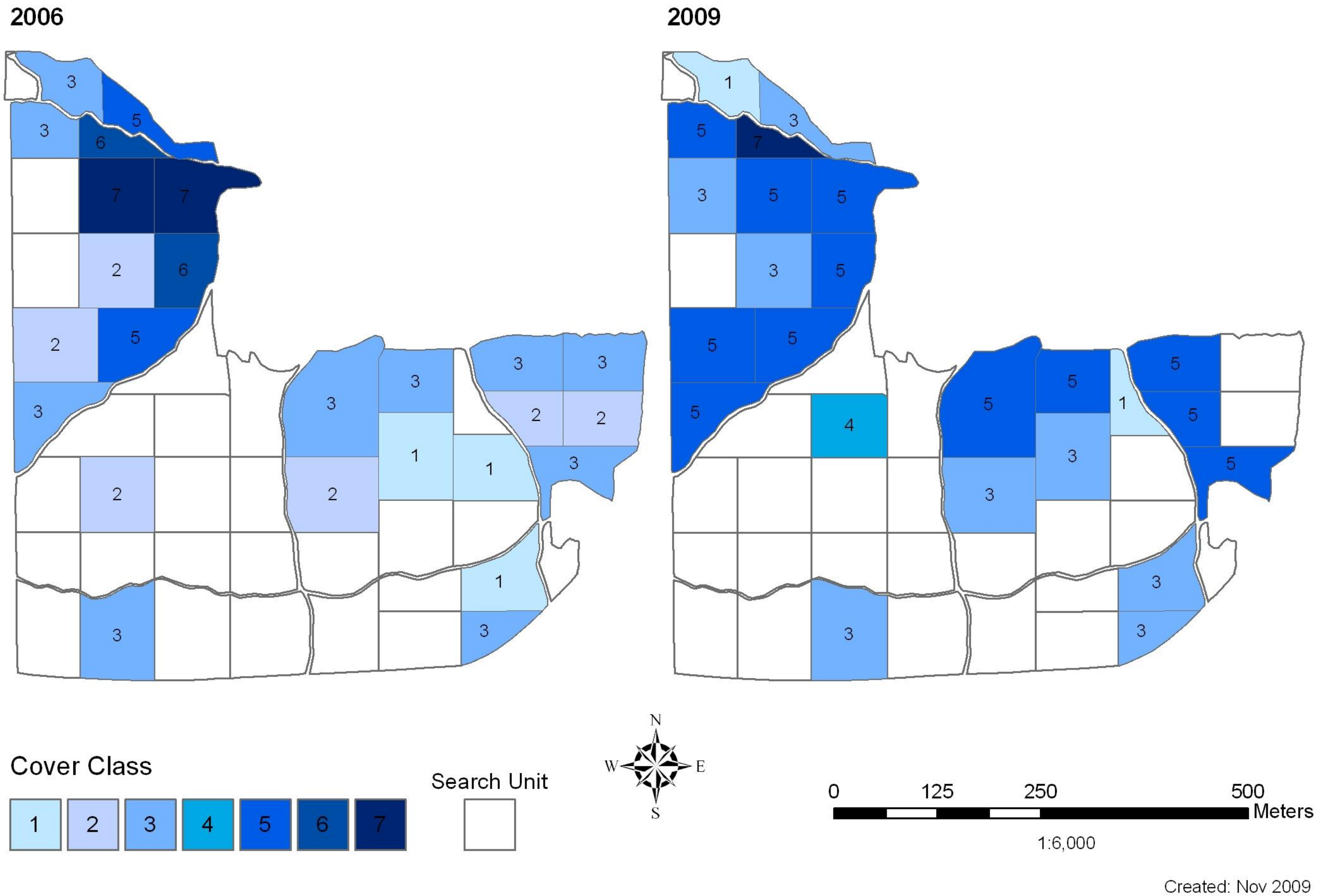

Figure 19. Abundance and distribution of *Phalaris arundinacea* (reed canarygrass) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Phleum pratense

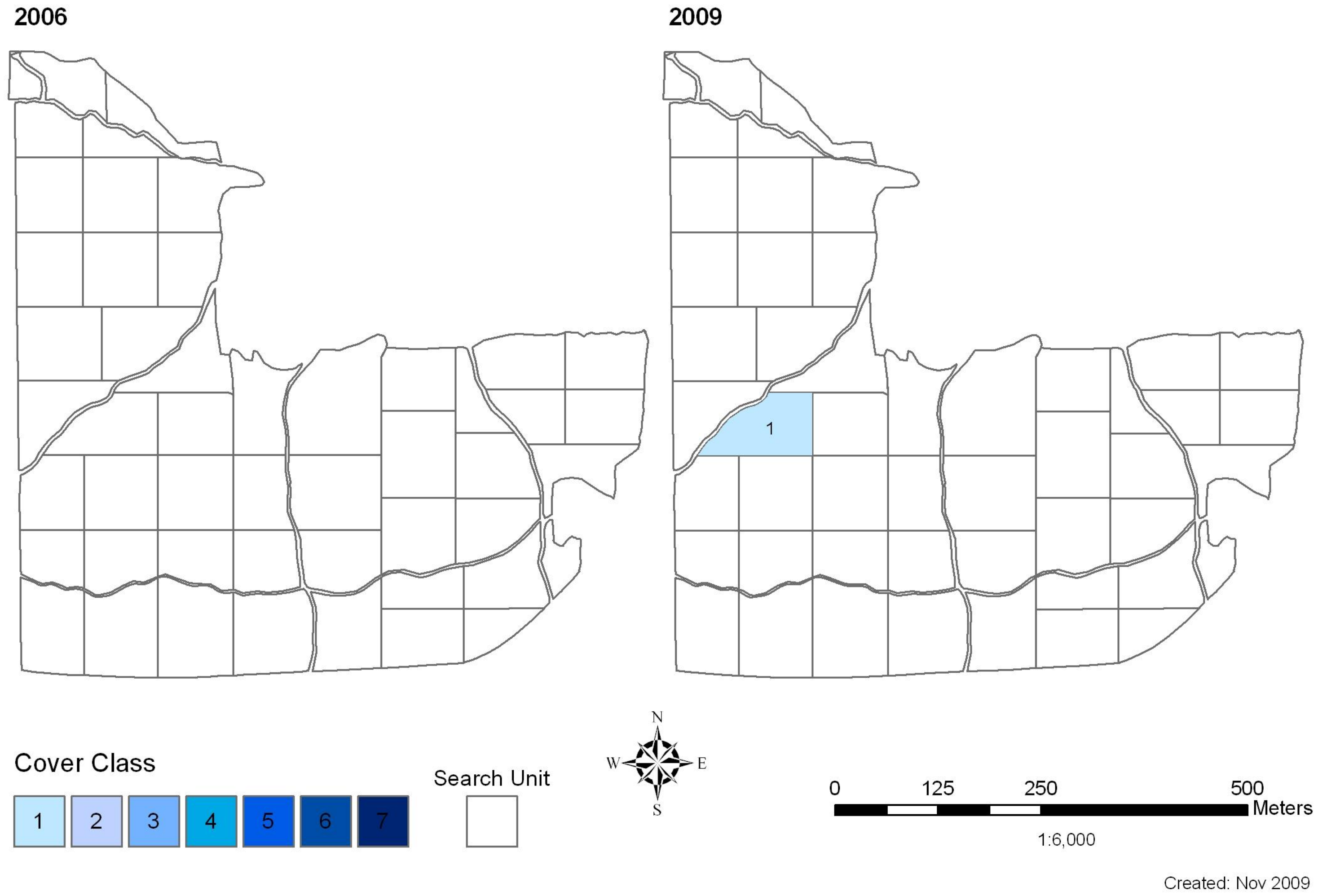

Figure 20. Abundance and distribution of *Phleum pratense* (Timothy) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m²**.**

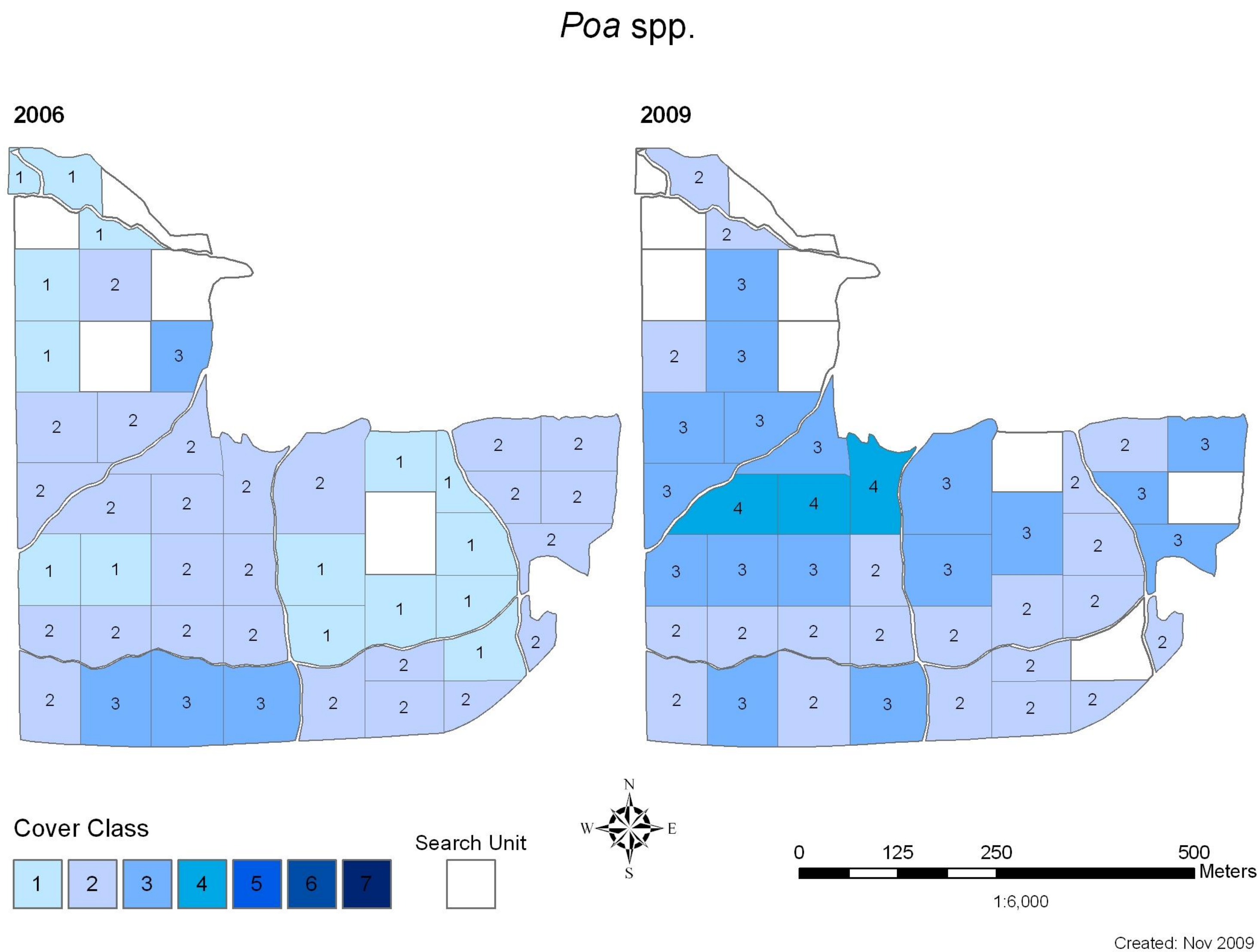

Figure 21. Abundance and distribution of *Poa* spp. (Kentucky and Canada bluegrass) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

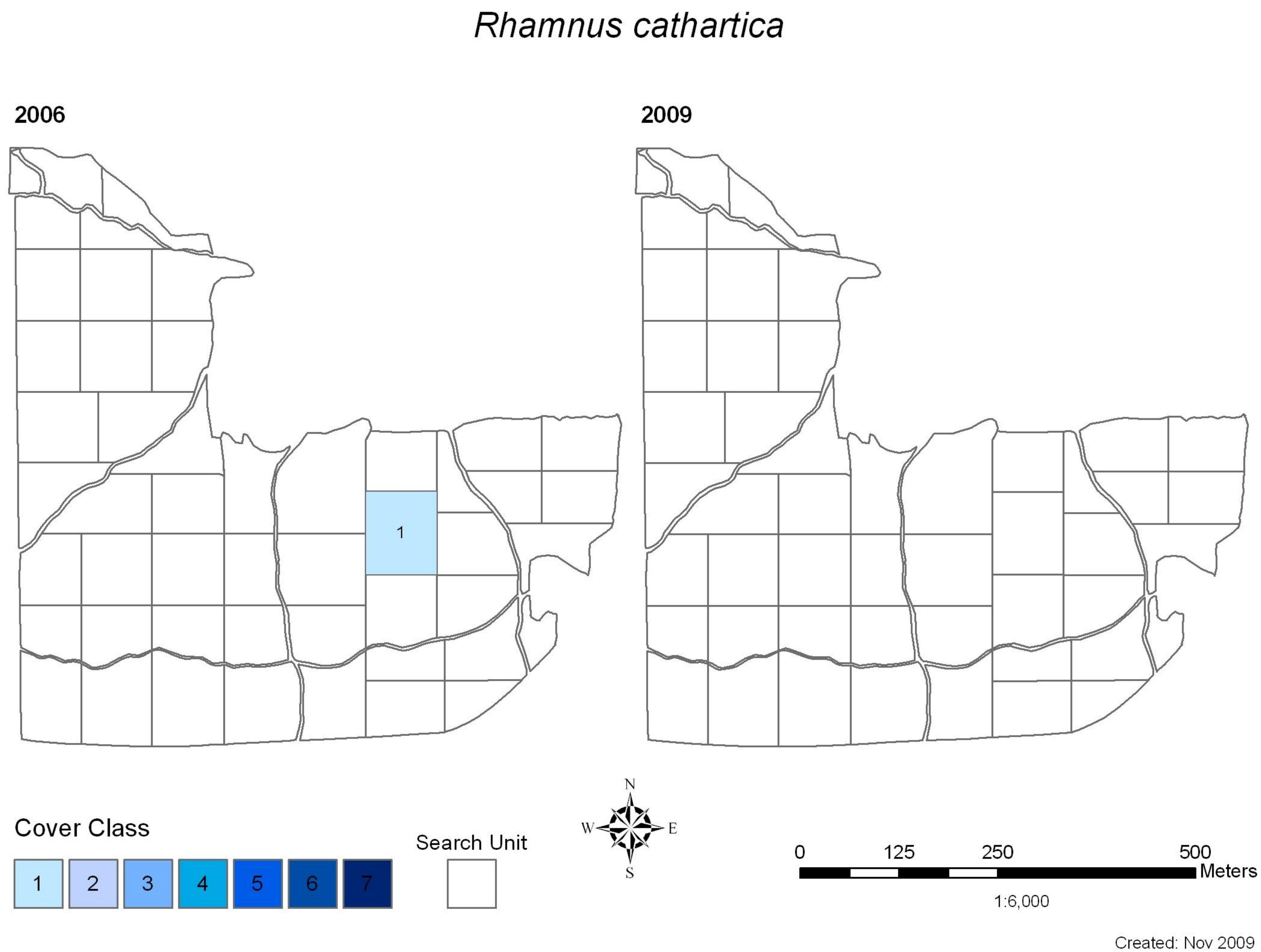

Figure 22. Abundance and distribution of *Rhamnus cathartica* (common buckthorn) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Rosa multiflora

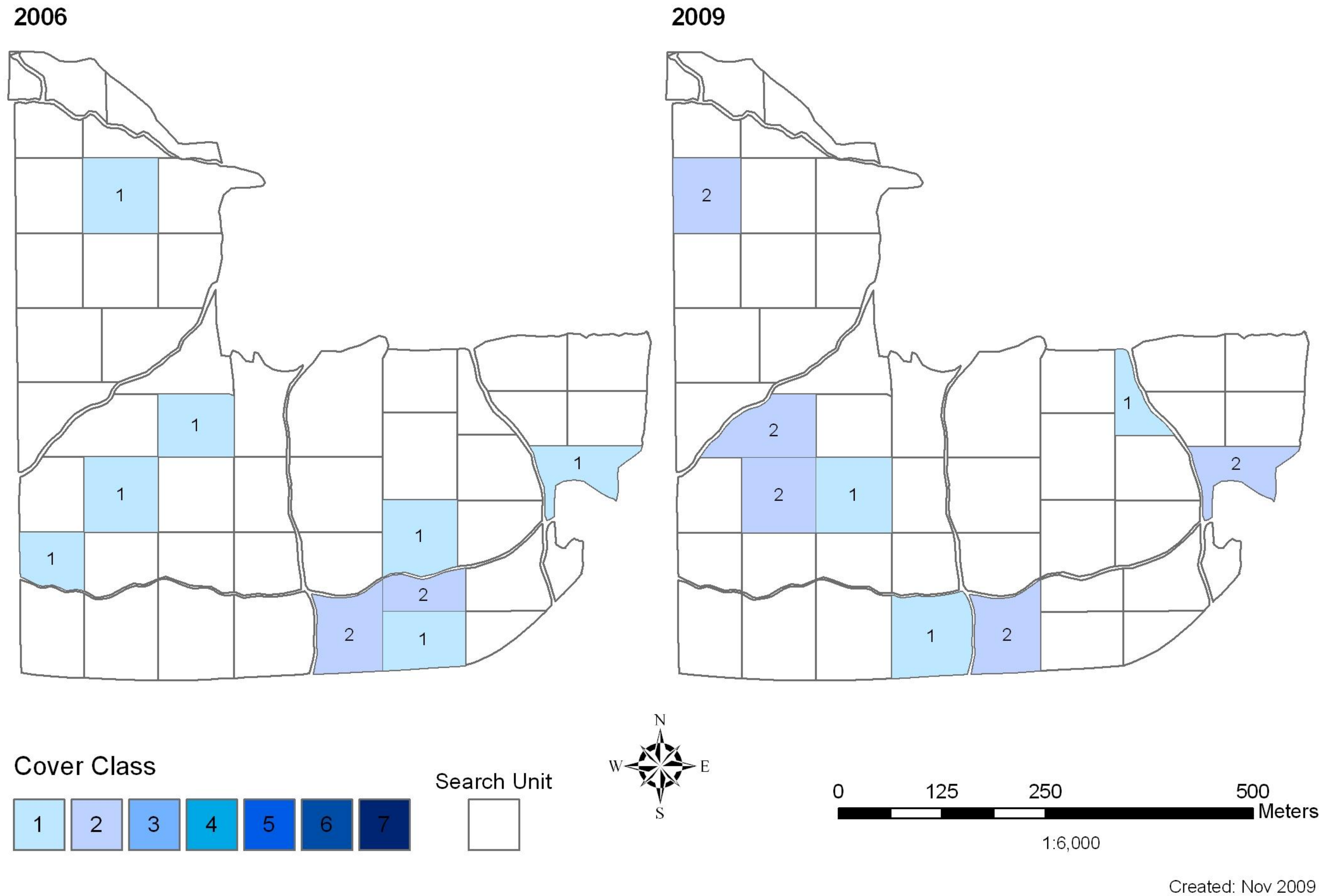

Figure 23. Abundance and distribution of *Rosa multiflora* (multiflora rose) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

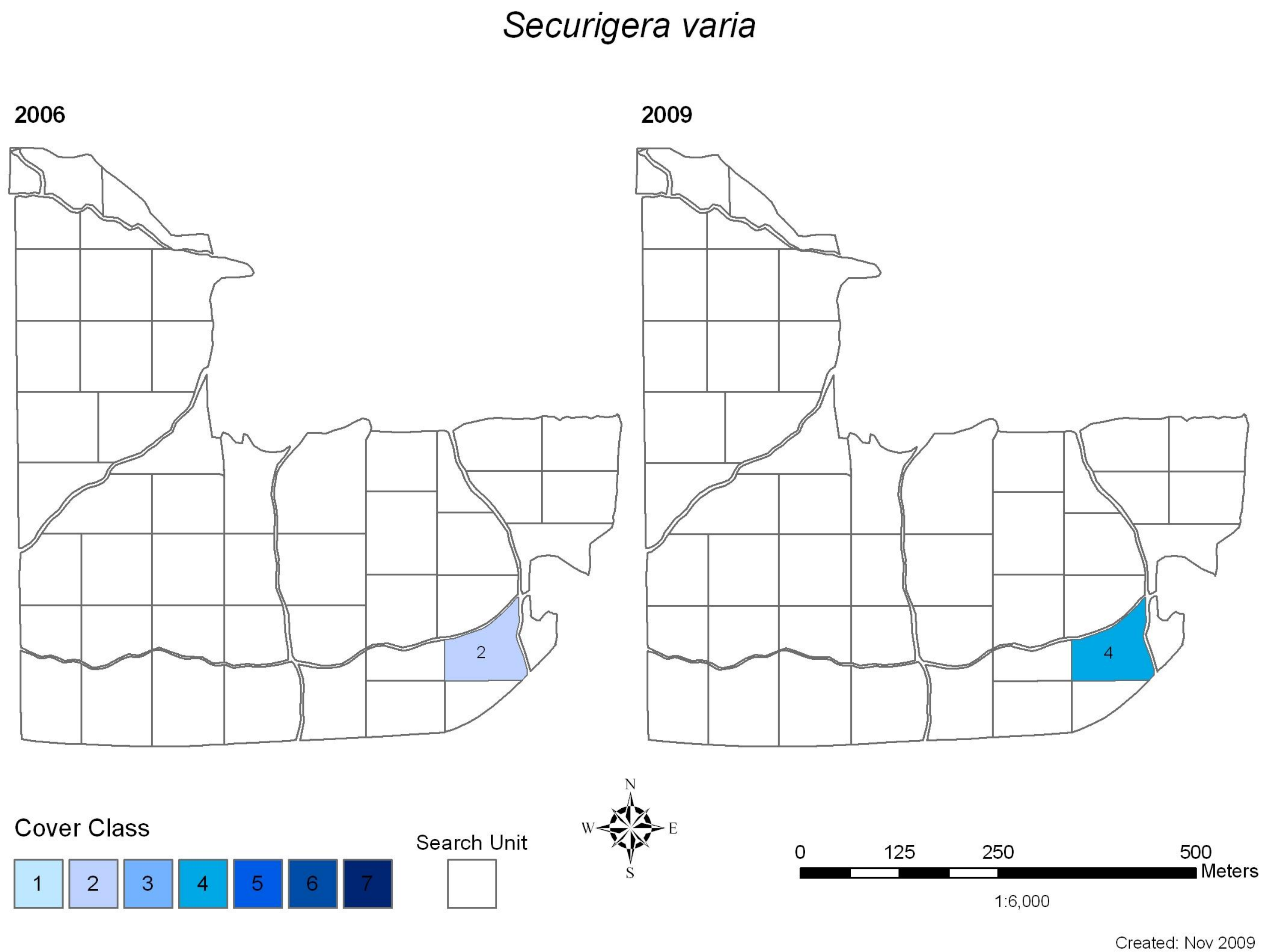

Figure 24. Abundance and distribution of *Securigera varia* (crownvetch) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m².

Sonchus arvensis

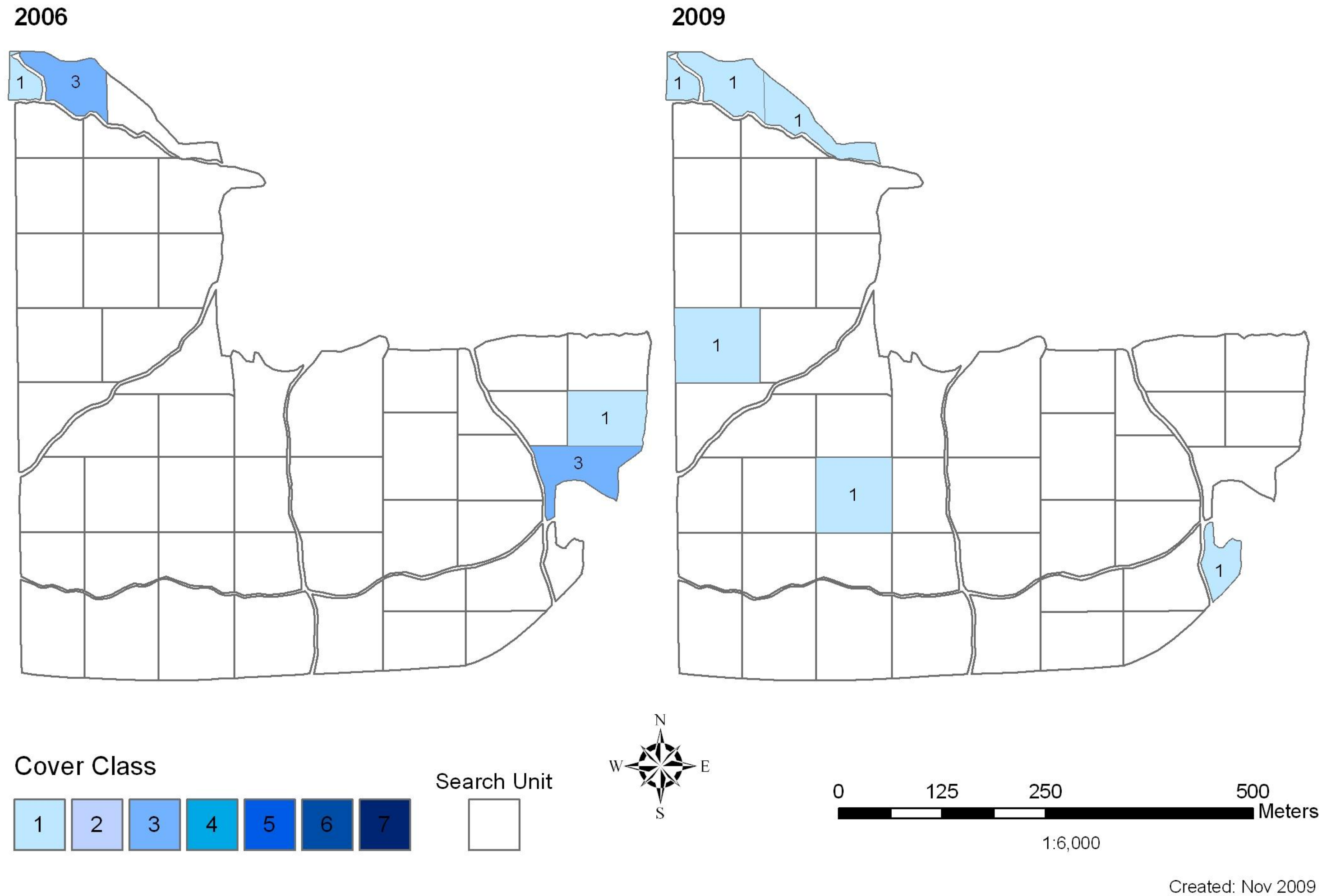

Figure 25. Abundance and distribution of *Sonchus arvensis* (field sowthistle) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

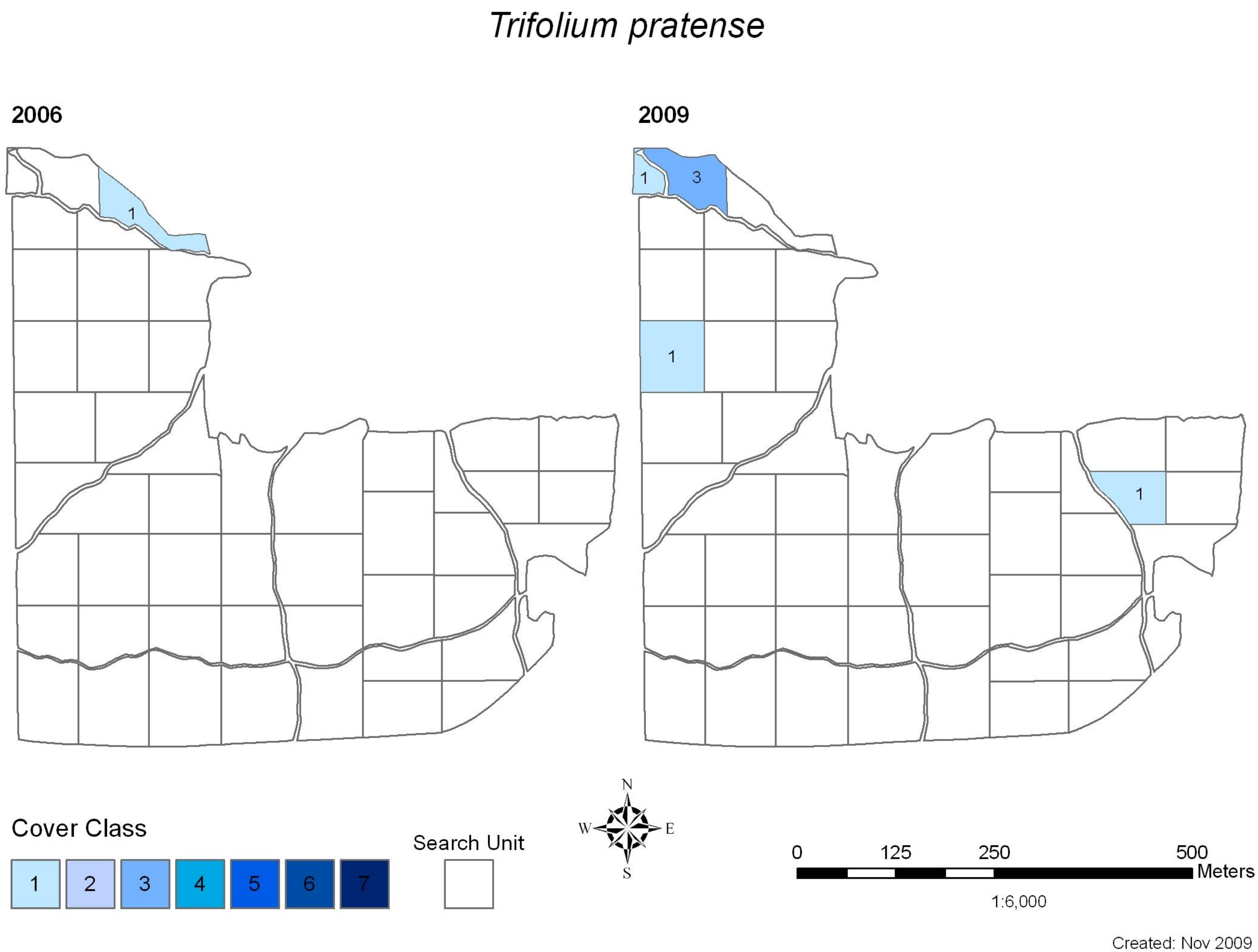

Figure 26. Abundance and distribution of *Trifolium pratense* (red clover) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

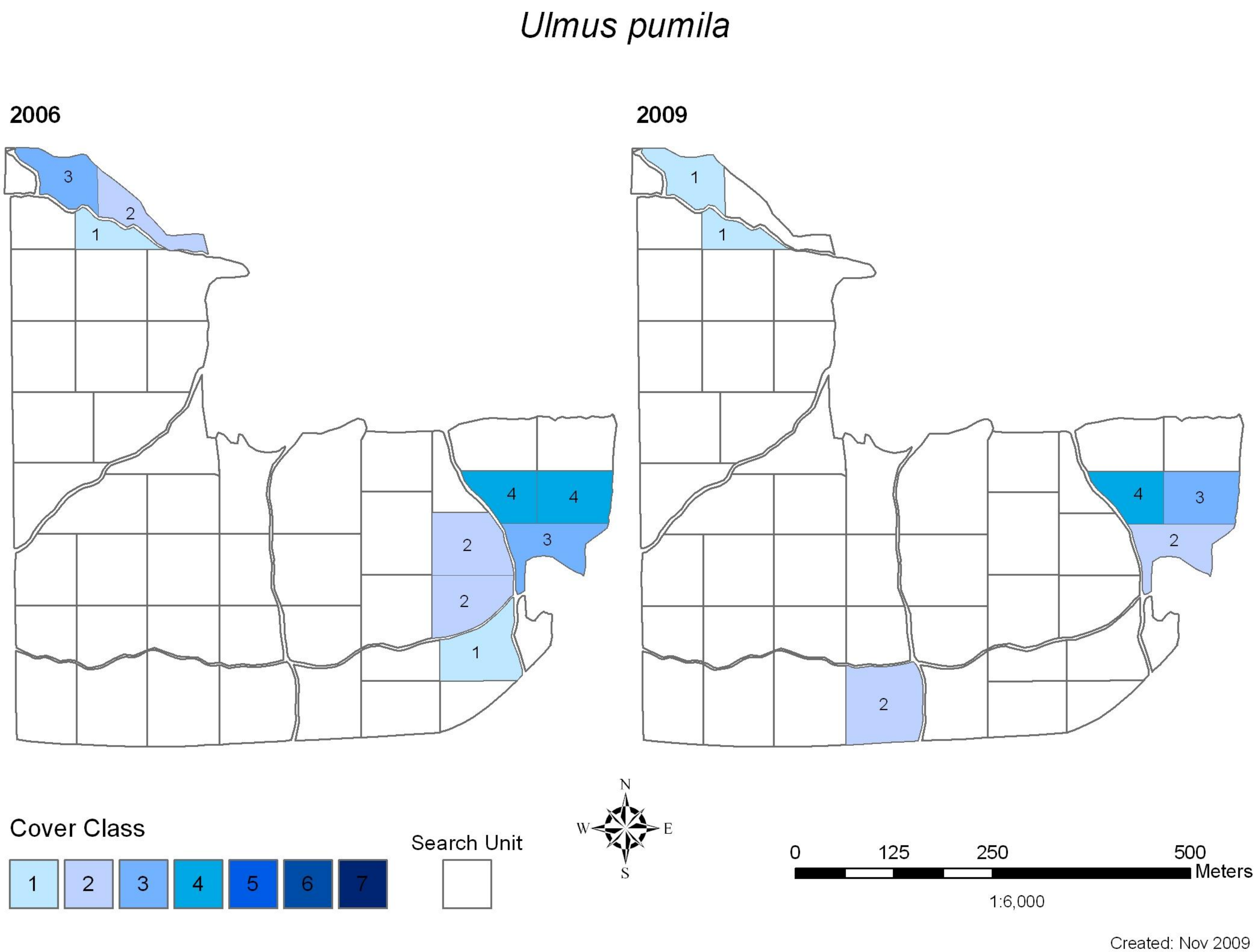

Figure 27. Abundance and distribution of *Ulmus pumila* (Siberian elm) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

Verbascum thapsus

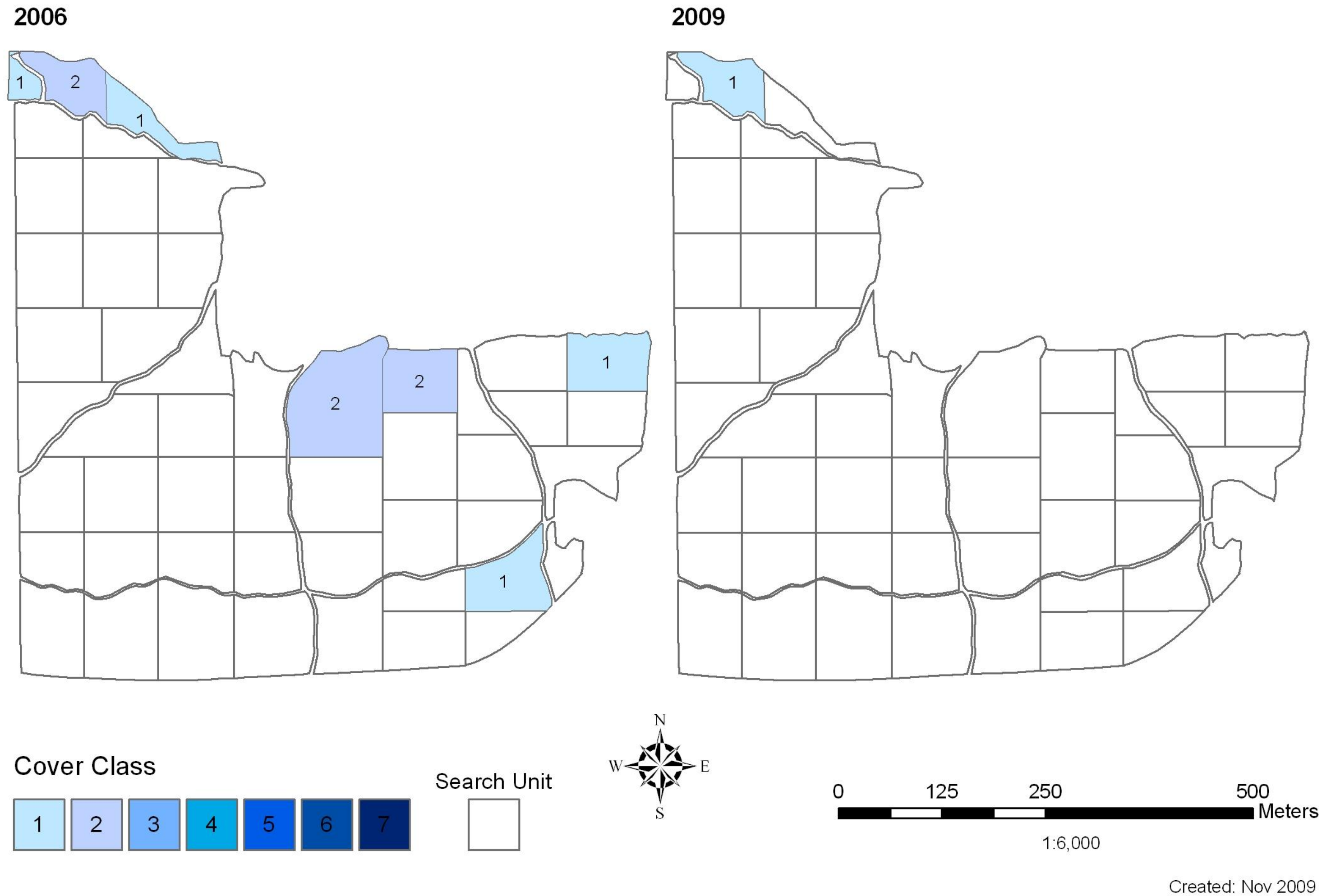

Figure 28. Abundance and distribution of *Verbascum thapsus* (common mullein) at **Herbert Hoover National Historic Site**, 2006 and 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network
Natural Resource Monitoring

NPS 432/101123, February 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov